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Final

Feasibility Study
SWMUs 1, 15, & 24

Naval Air Station, Oceana
Virginia Beach, Virginia

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Contract No. N62470-93-D-4072
CTO-0105

August 2001

Prepared by

CH2MHILL

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

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Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command
Norfolk, Virginia

Contract N62470-93-D-4072
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Acronyms and Abbreviations

AD	Average Daily Intake
AP	Applied Environmental Inc.
ARAR	Applicable or Relevant and Appropriate Requirement
AT	Averaging Time
bgs	Below Ground Surface
BRA	Baseline Risk Assessment
BW	Body Weight
C	Concentration
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund)
CF	Conversion Factor
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action Navy
COPC	Chemical of Potential Concern
CR	Contact Rate
CSF	Carcinogenic Slope Factor
CTO	Contract Task Order
CWA	Clean Water Act
cy	Cubic Yards
DAF	Dilution and Attenuation Factor
ECLR	Excess Lifetime Carcinogenic Risk
ED	Exposure Duration
EF	Exposure Frequency
EPA	U.S. Environmental Protection Agency
ERA	Ecological Risk Assessment
FFA	Federal Facilities Agreement
FS	Feasibility Study
FWEI	Foster Wheeler Enviresponse Inc.
H	H-Statistic
HEAST	Health Effects Assessment Summary Tables
HELP	Hydrologic Evaluation of Landfill Performance
HH	Human Health
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
HQ	Hazard Quotient
HRDS	Hampton Rhodes Sanitation District
HSDB	Hazardous Substances Data Base

Acronyms and Abbreviations (Continued)

IAS	Initial Assessment Study
IR	Installation Restoration
IR	Soil Ingestion Rate
IRI	Interim Remedial Investigation
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	Lowest Observed Adverse Effects Level
LTM	Long-term Monitoring
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MF	Modification Factor
mg/day	Milligrams per Day
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MIP	Membrane Interface Probe
MLW	Mean Low Water
msl	Mean Sea Level
n	Sample Size
NAB	Naval Amphibious Base
NAVFAC	Naval Facilities Engineering Command
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NFESC	Naval Facilities Engineering Service Center
NI	Nutrient Intake
NM	Normal Arithmetic Mean
NOAEL	No Observed Adverse Effect Level
NPL	National Priorities List
O&M	Operations and Maintenance
OMB	Office of Management and Budget
ORC	Oxygen Release Compound
ORP	Oxidation Reduction Potential
OSWER	Office of Solid Waste and Emergency Response
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
ppb	Parts Per Billion
PPE	Personal Protective Equipment
ppm	Parts Per Million
PRAP	Proposed Remedial Action Plan
PRG	Preliminary Remediation Goal
PVC	Polyvinyl Chloride

Acronyms and Abbreviations (Continued)

RA	Risk Assessment
RAGS	Risk Assessment Guidance for Superfund
RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RDA	Recommended Dietary Allowance
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RVS	Round 1 Verification Step
S	Standard Deviation of the Transformed Data
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SMCL	Secondary Maximum Contaminant Level
SS	Site Screening
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
T	T-Statistic
TAL	Target Analyte List
TCL	Target Compound List
TM	Transformed Mean
TOC	Total Organic Carbon
TOX	Total Organic Halogens
TPH	Total Petroleum Hydrocarbon
UCL	Upper Confidence Limit of the Mean
UF	Uncertainty Factor
USC	United States Code
USDA	U.S. Department of Agriculture
US EPA	U.S. Environmental Protection Agency
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation
VOC	Volatile Organic Compound
VSWCB	Virginia State Water Control Board
VWQS	Virginia Groundwater Quality Standards
WQS	Water Quality Standards
YC	Yorktown Confining Unit
YF	Yorktown Formation Aquifer Unit

Executive Summary

This report presents the Feasibility Study (FS) for SWMUs 1, 15, and 24 at the Naval Air Station (NAS), Oceana in Virginia Beach, Virginia. SWMU 1 is the West Woods Oil Disposal Pit, SWMU 15 is the Abandoned Tank Farm, and SWMU 24 is the Bowser at Building 840. This FS report is prepared by CH2M HILL under the Naval Facilities Engineering Command, Atlantic Division (LANTDIV), Comprehensive Long-term Environmental Action Navy II (CLEAN II) Contract N62470-93-D-4072, Contract Task Order (CTO) 105, for submittal to LANTDIV, U.S. Environmental Protection Agency (US EPA), and the Virginia Department of Environmental Quality (VDEQ).

This report uses information gathered from various previous SWMU investigations to document the analyses and evaluations used to develop remedial action objectives (RAOs) and alternatives for SWMUs 1, 15, and 24. The information presented herein will be used by the Navy and regulatory agencies to select a cost-effective remedial alternative for each SWMU that complies with the requirements of the National Contingency Plan (NCP).

Site-specific RAOs were developed for SWMUs 1, 15, and 24, based upon the results of previous investigations and risk assessments. The site-specific RAO for SWMU 1 is to prevent unacceptable risks to potential human receptors to the groundwater. The site-specific RAOs for SWMU 15 are: (1) Minimize direct contact of human receptors with surface soil that may pose unacceptable risks, (2) Minimize direct contact of ecological receptors with surface soil that may pose unacceptable risks, and (3) prevent unacceptable risks to potential receptors to the groundwater (consumptive and non-consumptive). The site-specific RAO for SWMU 24 is to prevent unacceptable risks to potential receptors to the groundwater.

Several potential remedial alternatives which would be suitable to address the RAOs were selected and evaluated for each SWMU based upon the criteria set forth in the NCP to assemble and evaluate technical and policy considerations and to develop rationale for selecting a remedy for each SWMU. The three remedial alternatives considered for SWMU 1 are: (1) no action, (2) free-product removal with institutional controls and long term monitoring, and (3) application of oxygen release compound and free-product removal with institutional controls and long term monitoring. The four remedial alternatives considered for SWMU 15 are: (1) no action, (2) landfarming the soil and monitored natural attenuation of groundwater with institutional controls, (3) landfarming the soil and long term monitoring of groundwater with institutional controls; and (4) downgradient reactive curtain of Oxygen Release Compound (ORC), long-term monitoring of groundwater with institutional controls, and landfarming. The three remedial alternatives considered for SWMU 24 are: (1) no action, (2) institutional controls with long term monitoring, and (3) application of oxygen release compound with institutional controls and long term monitoring.

Results of the criteria evaluation indicate that the most appropriate remedial alternative for SWMU 1 is free-product removal with institutional controls and long term monitoring. The most appropriate remedial alternative for SWMU 15 is landfarming the soil and long term

monitoring of groundwater with institutional controls. The most appropriate remedial alternative for SWMU 24 is institutional controls with long term monitoring. These selected alternatives for SWMUs 1, 15, and 24 meet all NCP criteria in the most appropriate, applicable, and cost effective manner.

1.0 Introduction

This report presents the FS for SWMUs 1, 15, and 24 at NAS Oceana, located in Virginia Beach, Virginia. SWMU 1 is the West Woods Oil Disposal Pit, SWMU 15 is the Abandoned Tank Farm, and SWMU 24 is the Bowser at Building 840. This FS report is prepared by CH2M HILL under the LANTDIV CLEAN II Contract N62470-93-D-4072, CTO-105, for submittal to LANTDIV, USEPA, and the VDEQ.

1.1 Objectives

This FS has been developed in accordance with the Navy's Installation Restoration Program (IRP). Previous SWMU investigations have been conducted under provisions of the Resource Conservation and Recovery Act (RCRA) Corrective Action program. As of July 1998, cleanup activities have been accomplished under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), within the framework of a new administrative procedure. Under the new administrative procedure, the Navy and the EPA have reached concurrence on the classification of each SWMU through a Federal Facilities Agreement (FFA) in lieu of scoring each SWMU for the National Priorities List (NPL). If the FFA process fails then the base will be subject to listing on the NPL. The FFA will supercede and rescind the RCRA 3008 (h) consent order. However, the EPA can still stipulate penalties through the FFA.

This report uses information gathered from various investigations, including the following: the Phase III RFI, Corrective Measures Study, Close-out Report for SWMU 15 Biopile soil, Monitored Natural Attenuation Study for SWMU 15, and Groundwater sampling at SWMUs 1 and 24. These and other previous investigations were used as a basis for developing and evaluating cost-effective remedial alternatives to address contamination at SWMUs 1, 15, and 24. The remedial alternatives are designed to address remedial action objectives (RAOs) and risks associated with SWMUs 1, 15, and 24 that are consistent with the National Contingency Plan (NCP). This FS includes a site-specific explanation of how each alternative satisfies the NCP's nine site-specific remedy selection criteria.

This FS documents the analyses and evaluations used to develop remedial action alternatives for SWMUs 1, 15, and 24. The information presented herein will be used by the Navy and regulatory agencies to select a cost-effective remedial alternative that complies with the requirements of the NCP. This FS is not intended to be a design document, rather, it gives a conceptual overview of alternatives to evaluate their feasibility. The report documents criteria used to evaluate remedial alternatives and to determine the effects of implementing them.

Section 1.0 provides a brief overview of the SWMUs, the nature and extent of contamination, and human health risk assessment for SWMUs 1, 15, and 24, as is required to introduce the remedial alternatives. More thorough discussion of the SWMUs, the remedial investigation activities and results, fate and transport, and the human health risk assessment can be found in reports under separate cover as documented in Section 1.4.

1.2 Report Organization

This FS report is comprised of the following sections:

- Section 1.0 - Introduction
- Section 2.0 - Remedial Action Objectives and ARARs
- Section 3.0 - Development of Remedial Alternatives
- Section 4.0 - Detailed Analysis of Remedial Alternatives
- Section 5.0 - Comparative Analysis and Recommended Alternative
- Section 6.0 – References

Figures and tables referenced within the text are provided at the end of each section.

1.3 Base Location and History

NAS Oceana has been in existence since 1940 when it was established as a small auxiliary airfield. Since 1940, NAS Oceana has grown to more than 16 times it original size and is now a 6,000-acre master jet base supporting a community of more than 9,100 Navy personnel and 11,000 dependents. The primary mission of NAS Oceana is to provide the personnel, operations, maintenance, and training facilities to ensure that fighter and attack squadrons on aircraft carriers of the U.S. Atlantic Fleet are ready for deployment.

In 1981, NAS Oceana initiated a comprehensive hazardous waste collection and recycling program to prevent releases of hazardous wastes to the environment. The program involves the use of waste controls such as oil and water separators near aircraft cleaning and maintenance areas, and working closely with various shops to ensure that wastes are properly contained, segregated, labeled, and collected. NAS Oceana also monitors discharges within drainages on and off the station as part of its National Pollution Discharge Elimination System (NPDES) monitoring to prevent the discharge of contamination beyond the limits of the station.

1.3.1 Climate

NAS Oceana is near the Atlantic Ocean (Figure 1-1), which accounts for the mild year-round temperatures. The Virginia Beach area climate is characterized by hot, humid summers and mild winters. The annual average temperature is 68.2 degrees. The average annual precipitation is 44.62 inches. Seasonal snowfall is approximately 7 inches annually. Average wind speed at the station is approximately 10 mph. Coastal storms, in the form severe thunderstorms, northeasters, and hurricanes, frequently impact the station.

1.3.2 Topography

The elevation of NAS Oceana ranges from approximately 5 feet above mean sea level (MSL) in the drainage ditches to approximately 25 feet above MSL in the open fields. Elevations in the developed area of the station range from 10 to 25 feet above MSL. Topography of the station is generally flat with a gradual easterly slope to the land surface.

1.3.3 Soils

NAS Oceana is on the outer edge of the Atlantic Coastal Plain physiographic province. The Atlantic Coastal Plain is a broad wedge of unconsolidated sediments that dip and thicken to the east. In the vicinity of NAS Oceana, the sediments consist of several thousand feet of unconsolidated sand, clay, silt, and gravel, and are underlain by granite basement rock. The sediments range in age from early Cretaceous to Recent. From oldest to youngest, the four geologic units underlying NAS Oceana are (1) the Potomac Formation, (2) the Pamunkey Group, (3) the Chesapeake Group, and (4) the Columbia Group (Meng and Harsh 1984). The geologic units of concern in the environmental investigations at the NAS Oceana are in the Chesapeake Group (only the youngest unit, the Yorktown Formation) and the Columbia Group.

The Chesapeake Group has been differentiated into several units, which are, from oldest to youngest, the Calvert, Choptank, St. Mary's, Eastover, and Yorktown Formations. As mentioned above, only the Yorktown Formation is of potential concern at NAS Oceana. The Yorktown Formation consists of interbedded layers of shelly, very fine to coarse sands, clayey sands, and sandy clay. Siudyla *et al.* (1981) divided the Yorktown into three sand units each overlain by a confining layer of silt and clay. Regionally, the uppermost of these silt and clay beds, which is referred to as the Yorktown confining unit, separates the Yorktown Formation from the sediments of the Columbia Group that overlie it. This uppermost bed consists of massive, well-bedded yellow-gray to greenish-gray clays and silty clays, which commonly contain shells, fine sand, and mica. The clay layers within the confining bed are generally extensive but are a series of coalescing clay beds rather than a single deposited unit. This unit was deposited in a shallow open-marine environment of broad lagoons and quiet bays (Meng and Harsh 1984).

The sediments of the Columbia Group consist of interbedded gravel, sands, silts, and clays of Pleistocene and Holocene age. The Pleistocene and Holocene sediments were deposited in fluvial-marine terrace and near-shore marine environments, including lagoons, beaches, tidal flats and barrier islands (Oaks and Coch 1973; Hamilton and Larson 1988). The Columbia Group sediments are, from oldest to youngest, (1) the Great Bridge Formation, (2) the Norfolk Formation, (3) the Londonbridge Formation, and (4) the Sand Bridge Formation (Oaks and Coch 1973).

The Sand Bridge Formation consists of a pale, yellowish-brown silt to sandy silt, often characterized as being clayey. This formation extends from the surface to a depth of 3 to 6 feet. Underlying the Sandbridge Formation is the Londonbridge Formation, a bluish-gray, fine silty sand, which is generally 4 to 5 feet thick. The third member of the Columbia Group encountered while drilling at the NAS Oceana is the Norfolk Formation. This formation, which is approximately 8 to 11 feet thick, is a bluish-gray to gray, fine to medium sand with trace shell fragments. The Great Bridge Formation underlies the Norfolk. The Great Bridge has an upper and lower member. The upper member is a white to light gray, well-graded sand. The lower member exhibits similar grain sizes and colors, but contains minor amounts of pebble gravel and bluish shell fragments. The Great Bridge Formation ranges in thickness from 0 to 55 feet.

1.3.4 Surface Water Resources

Surface runoff from the station is facilitated by a system of drainage ditches and surface canals that flow southwest to West Neck Creek, north to London Bridge and Great Neck Creek, and east to Owls Creek and Lake Rudee. The presence of iron precipitate, organic odors, high turbidity, and thick brown algae mats in many ditches was noted during early field investigations.

1.3.5 Groundwater Resources

Groundwater at NAS Oceana is generally within 4 to 10 feet of the ground surface. Aquifer conditions are unconfined in the Columbia Group and unconfined to semiconfined within the upper Yorktown Formation (Siudyla *et al.* 1981). When the clay confining unit overlying the Yorktown is absent, the upper Yorktown is generally unconfined. Natural groundwater flow directions are generally south to southeast, but flow direction is controlled locally in the Columbia Group by drainage ditches. The flow direction in the Virginia Beach area is therefore highly variable because of the complexity of the drainage patterns.

Generally, hydraulic conductivity values range from approximately 4.1×10^{-3} to 3.9×10^{-4} cm/second. Using an effective porosity of 25 percent and an average gradient of 0.0015 ft/foot the groundwater velocity in the Columbia Aquifer ranges from 2.2 feet per year in the silty sand to 24 feet per year in the medium grained sand with an average velocity in the aquifer of 9.9 feet per year.

There are seven wells on the base that extract groundwater from the subsurface. The locations of these wells are illustrated on Figure 1-2. Two of the seven wells (designated WS-5 and WS-7) extract groundwater from the Columbia Aquifer. The others extract water from the underlying Yorktown Aquifer. Of the two wells in the Columbia Aquifer one supplies water to a maintenance sink. The other well supplies a guard house bathroom. Both are posted as "Not for drinking water."

1.3.6 Habitats and Biota

This section documents the flora, fauna, and rare, threatened, or endangered species observed at NAS Oceana.

1.3.6.1 Flora

A wide variety of vegetation types occur at NAS Oceana. Approximately 600 acres of forest and 200 acres of open land comprise the undeveloped areas at NAS Oceana (RGH 1984). Approximately 660 acres (11 percent) of the land area at NAS Oceana are wetlands.

Most of the forested areas on the station are dominated by pine, mixed pine-hardwood, and hardwood stands. Areas with poorly drained, saturated soils are dominated by sweetgum, red maple, and, sometimes, loblolly pine. Most forested stands with unsaturated or moist soil conditions are dominated by loblolly pine or mixed pine-hardwoods. Upland forested areas usually have more oaks and cherry. Other overstory species likely to occur with these species are water oak, southern red oak, swamp chestnut oak, willow oak, tulip poplar, and black gum. Understory vegetation in the hardwood stands is dominated by switch cane. Other species occurring in the hardwood understory include greenbriar, pawpaw, Japanese

honeysuckle, and bayberry. Understory plants that commonly occur in loblolly forests include sparse stands of switch cane, greenbriar, and Japanese honeysuckle.

1.3.6.2 Fauna

Mammalian species such as white-tail deer, raccoon, chipmunk, squirrel, field mouse, and red fox inhabit the forested areas around NAS Oceana or in over-grown areas in the developed section of the station. Many species of birds use the station as seasonal and year-round habitat including the yellow-rumped warbler, which occurred in large numbers on the edges of forested areas throughout the station, and starlings, crows, gulls, song sparrows, ovenbirds, blue jays, cardinals, and common flickers. Habitat exists on the station for a wide variety of reptiles and amphibians including eastern painted turtles, slider turtles, green frogs, and bullfrogs. Fishery resources are largely limited to the ponds at the inactive landfill/sand pit, and the borrow pond on the outskirts of the station. Largemouth bass and bluegill are known to exist in these ponds. Some of the creeks on the station have low numbers of mosquito fish and mud minnows.

1.3.6.3 Rare, Threatened, and Endangered Species

An inventory of rare, threatened, and endangered vertebrate and plant species was conducted on NAS Oceana in 1989 by the Virginia Department of Conservation and Recreation, Division of Natural Heritage (DNH), and was published in a Natural Heritage Technical Report (DNH 1990). These results were updated and verified by checking the DNH, VA Department of Game and Inland Fisheries, and USFWS web sites for rare and endangered species. The updated information, in conjunction with the earlier DNH report (DNH 1990) suggests that no rare, threatened, or endangered wildlife species are known to occur at NAS Oceana, with the possible exception of occasional transient species (CH2M HILL 1993). These species are discussed below. Several rare plant species have been found on the station (see below).

Wildlife. The following three listed species reside or migrate through southeastern Virginia and could be found at the station:

- Peregrine falcon (*Falco peregrinus*). Listed as endangered in the commonwealth of Virginia, the peregrine falcon can be found in coastal areas during migration, particularly in September and October. In addition, hacking stations (release areas) have been established for the peregrine falcon on the Eastern Shore and in Back Bay National Wildlife Refuge (RGH 1984).

- Bald eagle (*Haliaeetus leucocephalus*). This species is listed as threatened in the commonwealth of Virginia and in portions of the lower 48 United States. The bald eagle was proposed for removal from the federal list in July 1999. Virginia provides prime habitat for the bald eagle. In 1978, 37 active nests were located in the state (RGH 1984). There are currently no known bald eagles nesting in the immediate area of NAS Oceana. Some birds, however, do winter along area beaches or pass through the region during migration.

- Swainson's warbler (*Limnothlypis swainsonii*). This species is known to inhabit areas with abundant giant cane. This habitat was once common in Virginia Beach and is found on

NAS Oceana. The findings of the DNH technical report (DNH 1990) are that only marginally suitable habitat was found at the station for this species.

A list of rare wildlife species that may occur in the vicinity of NAS Oceana was generated from the natural heritage database and is presented in the Final ERA (CH2M HILL 2001a).

Other rare, threatened, or endangered wildlife species that historically were likely to occur on the station are the following:

- Red-cockaded woodpecker (*Picoides borealis*)
- Many-lined salamander (*Stereochilus marginatus*)
- Greater siren (*Siren lacertina*)

The red-cockaded woodpecker was sighted in Suffolk, approximately 30 miles away from NAS Oceana, during the summer of 1984 (Nair 1988). No sightings have occurred since 1984. The many-lined salamander was found in a sandy-bottomed stream within a few miles of NAS Oceana, but the exact location of this sighting or the date could not be determined (DNH 1990). The greater siren was recorded early in this century and in the 1950s at Dam Neck Lake and Indian Creek (DNH 1990). No recent specimens of either of these salamanders are known.

Plants. A list of rare plant species that may occur in the vicinity of NAS Oceana was generated from the natural heritage database (DNH 1990). One state-listed rare plant species was observed during the on-site survey of the station. This species was the long-leaf pine (*Pinus palustris*), which is listed as extremely rare in Virginia. A grove of long-leaf pine was planted in the early 1980s near the sandpit area at Site 22 as an experiment to determine if the species could be successfully grown at NAS Oceana for commercial harvesting (CH2M HILL 1993). Commercial use of long-leaf pine at NAS Oceana was determined to be infeasible; however, the stand that exists on the site serves aesthetic purposes. The DNH did not consider this particular stand of long-leaf pines to be an important natural resource to be protected because the trees were planted (CH2M HILL 1993).

The southern twayblade (*Listera australis*) also is known to occur on the station. This species is listed as very rare in Virginia. Eighteen individuals were located during the species inventory conducted by DNH in 1989. The plants were found in the area referred to as the Northwest Woods Special Interest Area. *Listera australis* was recommended for special concern status in 1989 (DNR 1990).

1.4 SWMU Descriptions

The following subsections document the location and history, previous investigations, extent of contamination, and results of risk assessment at SWMUs 1, 15, and 24.

1.4.1 SMWU 1 – West Woods Oil Disposal Pit

The location and history, previous investigations, extent of contamination, and results of risk assessment at SWMUs 1 – the West Woods Oil Pit, follows.

1.4.1.1 Location and History

SWMU 1, the West Woods Oil Disposal Pit, is located in the northwest part of NAS Oceana, approximately 1,000 feet west of abandoned Runway 9 (Figure 1-2). According to the Initial Assessment Study (IAS), the SWMU was originally an open pit where about 110,000 gallons of waste oil, fuels (such as JP-5, JP-3, and aviation gas), PD 680, various chlorinated and aromatic hydrocarbons (trichlorotrifluoromethane, benzene, toluene, and naphtha), aircraft-maintenance chemicals, paints, paint thinners and strippers, and agitine, were disposed of from the mid-1950s to the late 1960s (RGH, 1984). Drilling at this unit has shown that metal, concrete, and other debris were also disposed of in the pit or were included in the fill material. A 1958 aerial photograph of the unit shows that the pit was approximately 50 to 100 feet in diameter.

In the late 1960s, the oil disposal pit flooded and its contents are believed to have washed into the main drainage ditch, 100 feet west of the pit. Waste disposal was discontinued and the pit was filled with soil (RGH, 1984). The NAS boundary is approximately 1,000 to 2,000 feet west or northwest of the oil pit. This engineered drainage ditch is part of the NAS Oceana stormwater and spill control system that is maintained, as required, to ensure designed functionality. As such, the NAS Oceana Environmental Division monitors the ditch downstream of SWMU 1 as part of the station's Virginia Pollution Discharge Elimination System (VPDES) monitoring program. The VPDES monitoring is required as the ditch is a spill control device, not to monitor contaminants. As the maintenance of this ditch is not on an established or regular cycle, the ecological habitat of these ditches in its current state was conservatively evaluated as an aquatic habitat in the ecological risk assessment performed at the site. The Final ERA for SWMU 1 concluded that this ditch has a low to negligible potential for risk to aquatic organisms.

The immediate area around the pit is dominated by trees, shrubs, grass, and herbs. Although forested in the past, the trees around the SWMU have been cut and the site and surrounding area is now maintained to limit the heights of woody plants. A small fresh-water emergent wetland is located approximately 250 feet east of the SWMU. The eastern perimeter of the SWMU is comprised of mowed and old field grasses and impervious surfaces. Surface drainage is directed toward north-south and east-west oriented drainage ditches. The north-south (main) drainage ditch has a permanent flow of surface water to the north. The ditch is approximately 12 to 15 feet wide with steep side slopes about 5 feet high. The ditch generally maintains a low-volume baseflow because it is excavated to a depth below the water table during normal precipitation conditions. No vegetation has been observed in the stormwater drainage ditch and the ditch receives periodic maintenance to maintain unimpeded stormwater conveyance. A second east-west trending tributary drainage ditch is located south of SWMU 1 and conveys stormwater drainage west into the main drainage ditch. This tributary ditch is perched approximately 2 feet above the base of the main drainage ditch and is dry except during heavy precipitation events. This ditch contains small shrubs and grass and oxidized, non-saturated soils. It does not provide significant habitat for aquatic life.

1.4.1.2 Previous Investigations

Previous investigations at SWMU 1 include: the Initial Assessment Study (IAS) in 1984, the Phase I Verification Study in 1986, the Interim RCRA Facility Investigation (RFI) in 1991, the

Phase I RFI in 1993, the Corrective Measures Study (CMS) in 1994, the Phase III RFI in 1997, and groundwater sampling in 1998.

The IAS, conducted in 1984, identified the site and inventoried the types of waste liquids disposed of in the pit. The Phase I Verification Study (CH2M HILL, 1986), and Interim RFI (CH2M HILL, 1991), showed that the groundwater is contaminated locally with compounds associated with petroleum hydrocarbons. Sediment samples collected from the drainage ditch west of the former oil disposal pit also contained petroleum constituents.

The Phase I RFI investigation (CH2M HILL, 1993) was conducted to determine the vertical and lateral extent of groundwater contamination and the hydraulic characteristics and flow regime of the shallow aquifer. The groundwater was sampled for Polycyclic Aromatic Hydrocarbons (PAHs) and Volatile Organic Compounds (VOCs). PAHs were not detected in groundwater. Benzene, toluene, ethylbenzene, and xylene were detected in groundwater in two of the six wells. Summing of the benzene, toluene, ethylbenzene and xylene to determine total BTEX indicated a detection of 67 µg/L in 1-MW4 and 16 µg/L in 1-MW5. 1,1-Dichloroethane (1,1-DCA) was also detected in 1-MW4 at 2 µg/L. Only one BTEX constituent, benzene, was detected in groundwater at concentrations that exceed a Maximum Contaminant Level (MCL). Benzene was detected at 6 µg/L (MCL = 5 µg/L) in well 1-MW4 (Figure 1-3). Well 1-MW4 also was reported to contain free product. However, other wells that contained free product were not reported to contain BTEX constituents at concentrations above the MCLs.

The Phase I RFI also characterized the type and extent of soil contamination around the pit and the extent of sediment and surface water contamination. High concentrations of petroleum hydrocarbon products were detected in several soil borings, including those north of the pit.

Subsequently, a CMS field investigation was performed (CH2M HILL, 1995b) to determine the extent of contamination in soil and develop remedial alternatives. The field investigation included trenching at the site to determine the thickness of free product in the subsurface. The trenching confirmed the presence of free product contamination in soil on top of the water table. Product thickness was determined to be approximately 0.04 feet. An extraction well and monitoring system were installed at SWMU 1 to test the viability of extracting free product from the top of the water table. Two pilot tests were completed, however, no free product was recovered during either test due to the tightness of the silts that contained the product. The CMS recommended pulsed-pump extraction of free product as the preferred remedial alternative at SWMU 1.

Groundwater sampling completed during the CMS indicated that groundwater is essentially not contaminated with dissolved-phase VOCs, however benzene was detected. BTEX constituents were not detected at concentrations above MCLs in the groundwater samples collected during the CMS.

In 1997, as part of the Phase III RFI (CH2M HILL, 1999b), the Navy installed two solar-powered skimmers and began recovering the free phase petroleum product found in 1-MW4, 1-MW5, 1-PZ3, and 1-PZ5 (Figure 1-3). These skimmers are presently in use for free-product removal from existing wells at the SWMU.

1.4.1.3 Contamination and Extent

SWMU 1 is underlain by silt, sand, and silty sand in three distinct lithologic units that are generally consistent across the site. The uppermost unit is a brown silt or sandy silt that is 4.5 to 6 feet thick and appears to have a low permeability. Beneath the silt, an 11- to 13-foot thick clean, fine, to very coarse gray sand extends to a depth of 16 to 19 feet. The shallow monitoring wells are screened in this sand unit. Underlying the clean gray sand is a third lithologic unit composed of very fine greenish-gray silty sand or sandy silt. The sand in this unit is extremely fine, only slightly coarser than a fine silt. The appearance of shells in this unit is coincident with the top of the Yorktown Formation. Deep wells are screened in this uppermost sandy unit of the Yorktown Formation. Shallow groundwater flow was determined to be westerly directed, towards the drainage ditch, which serves as a hydrologic boundary and place of discharge for the localized groundwater flow system. The depth to groundwater at SWMU 1 is generally 5-6 feet below ground surface. A geologic cross section of SWMU 1 is shown in excerpts from the CMS presented in Appendix A. The results of the most recent groundwater sampling are summarized in the next section and the entire *Final Technical Memorandum for the Groundwater Sampling at SWMU 1* is presented in Appendix B.

In November 1998, 15 groundwater samples were collected from 10 monitoring wells (MW02 through MW07, MW7D, MW8, MW8D, and MW10) and five piezometers (PZ01 through PZ05) at SWMU 1 in support of risk assessment and long-term monitoring.

In addition to the groundwater samples collected at SWMU 1, an attempt was made to collect free product samples from piezometers PZ03 and PZ05; monitoring wells MW04 and MW05; and two skimmer tanks located at SWMU 1. However, no product was available from the piezometers and the monitoring wells. On March 11, 1999 product accumulating in well MW04 was sampled and identified as degraded diesel fuel.

Analytical results of the groundwater sampling indicate that the shallow groundwater at SWMU 1 contains low concentrations of benzene and one PAH [benzo(a)pyrene] at concentrations that exceed MCLs and USEPA Region III RBCs for tap water.

The benzene concentration in sample PZ03 (6 µg/L) exceeded the MCL and the RBC. One benzo(a)anthracene concentration of 0.23 µg/L exceeded the RBC in the sample from monitoring well MW8D. Finally, benzo(a)pyrene was detected in the sample from PZ01 at 0.2 µg/L, and exceeded both the RBC and the MCL (Figure 1-3). The risks associated with groundwater contamination at SWMU 1 were quantified in the human health risk assessment. Additional surface soil, surface water, and sediment samples were also collected in July 1999 at SWMU 1 to determine the extent of contamination in support of ecological and human health risk assessment.

1.4.1.4 Human Health Risk Assessment

The human health risk assessment (HHRA) performed for SWMU 1 characterizes potential current and future risks to human health at the site using the general methodology described in the *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part A* (USEPA, 1989) and *RAGS, Volume 1, Human Health Evaluation Manual, Part D* (USEPA, 1998). Potential risks were calculated for a current industrial worker, current adult trespasser/visitor, current adolescent trespasser/visitor, future adult

resident, future child resident, future lifetime resident, future construction worker, future industrial worker, future adult trespasser/visitor, and adolescent trespasser/visitor. The HHRA determined the primary transport mechanism for contamination at SWMU 1 to be leaching from the soil to the groundwater and transport in the groundwater. Additionally, shallow groundwater discharges to the drainage ditch that is 100 feet west of the pit, and may result in some contamination being transported to the sediment and surface water in the ditch.

Potential risks were calculated for exposure to surface soil, combined surface and subsurface soil, groundwater, and sediment. Although the Columbia Aquifer groundwater is not currently used as a potable water supply and will most likely never be used as a potable water supply, potential future exposure to groundwater was evaluated under a future residential and construction worker exposure scenario.

No unacceptable risks were found to be present under current scenarios. However, a noncarcinogenic hazard greater than USEPA's target hazard index (HI) was determined to be present to a future child resident for potential exposure from combined surface and subsurface soil. This HI of 1.8 slightly exceeds USEPA's target HI of 1.0. This hazard is primarily associated with ingestion of iron. However, the HI was separated by target organ and each HI is below the target HI of 1.0. The CT noncarcinogenic hazard was calculated for the child resident exposed to combined surface and subsurface soil and is below USEPA's target HI.

In addition, the HHRA concludes future residential use of the groundwater would result in a noncarcinogenic hazard above USEPA's target HI for both a child and an adult. This hazard is primarily associated with the naphthalene detected in the groundwater. The HIs are 1.3 and 10, respectively. No unacceptable risks were found to be present for non-consumptive contact with the groundwater by a construction worker. Furthermore, no unacceptable risks were determined to be present from exposure to surface water or sediment in the drainage ditch.

Therefore, the only potential scenario resulting in hazards or risks above USEPA's target level is future residential use of the site. Future residential use of the site may result in an unacceptable HI to an adult and child resident exposed to groundwater. However, the future use of the site for residential purposes is highly unlikely.

1.4.1.5 Ecological Risk Assessment

The final ecological risk assessment (ERA) performed for SWMU 1 concluded that potential risks to soil invertebrates utilizing SWMU 1 are expected to be low to moderate but occur only in an isolated area (CH2M HILL, 2001a). The few COPCs that pose a risk in surface soil were generally consistent with basewide soil concentrations. No HQ for food web exposures for either terrestrial or aquatic receptors exceeded one based on a LOAEL. The ditch at SWMU 1 is part of an engineered stormwater and spill control system for NAS Oceana. This ditch is maintained, as required, to ensure designed functionality. As the maintenance of this ditch is not on an established or regular cycle, the ecological habitat of these ditches in its current state was conservatively evaluated as an aquatic habitat in the ecological risk assessment performed at the site. No COPC exceeded both a screening value and an upgradient concentration in surface water or sediment. Considering the relatively low habitat value of these ditches (which are periodically maintained as part of the stormwater

system) and the likelihood that upper trophic level receptors would forage elsewhere (where habitat quality was better) much of the time, risks to these species are likely to be negligible.

Based upon the results and the certainty associated with the results, the relative size of this SWMU, and the proximity of SWMU 1 to an active military runway/airfield, site specific toxicity testing or additional sampling on which to base remedial action decisions is not warranted. Therefore, no further study in the risk assessment is recommended at this time. The identified potential for risks to ecological receptors is further addressed below.

An air station-wide comparison was performed for surface soil, surface water, and sediment in order to determine whether or not concentrations of metals at SWMU 1 fell within the same range as metals across the air station. Appendix C provides the hypotheses tested and supporting data used in these comparisons. Confidence limits were calculated around the means of both the site-specific and the air station-wide concentrations in order to determine whether there was evidence that the chemicals were site-related.

According to the central tendency theory, when the site confidence limits overlap with the NASO-wide confidence limits, the null hypothesis is accepted. It can be concluded with 95% confidence that the two sets of data are not statistically different (i.e., they are from the same population) and that there is no evidence of site-relatedness. Table C-2 in Appendix C shows the ranges that were calculated for each COPC at SWMU 1.

Two metals (aluminum and iron) had mean HQs greater than one for surface water. In addition, the confidence limit comparison for surface water showed that iron concentrations in surface water at SWMU 1 are significantly different than the air station-wide concentrations. A source for these metals has not been identified and they are not believed to be site related. It is suspected that the chemicals could be coming from off site, upstream of the drainage ditch. Because the source is unknown, and because this is a dynamic drainage ditch system with constantly changing water concentrations, an appropriate treatment is not available. In addition, both aluminum and iron are naturally occurring metals. The Ambient Water Quality Criteria screening value used for aluminum is based on dissolved metals which are more bioavailable and therefore more toxic than metals bound to particulates. Site data are for total metals, which includes the particulate and dissolved fractions. Using this screening value gives a conservative estimate of risk for aluminum in surface water.

Based on the evidence presented above and the fact that the HQs for the metals are very low (both less than six), potential risk from metals in surface water to ecological receptors is negligible. Therefore, no remedial action is recommended for surface water at SWMU 1.

Seven PAHs had mean HQs greater than one in surface soils. However, all were less than two and occurred in localized areas. Based on this evidence, potential risk from PAHs in surface soils to ecological receptors is negligible.

Five metals had mean HQs greater than one in surface soil. There is no obvious source on the site for metals. The surface soil comparison showed that metal concentrations in surface soils at SWMU 1 are not significantly different than the air station-wide concentrations. Therefore, no remedial action is recommended for surface soils at SWMU 1.

In addition to the air station-wide parametric statistical comparison, the non-parametric Kruskal-Wallis test was performed using the soil, surface water, and sediment data to determine whether or not concentrations of metals at SWMU 1 fell within the same range as metals across the air station. Tables C-3 through C-5 present the results of this analysis. This comparison largely confirms the results of the parametric comparison. One difference was that the Kruskal-Wallis test indicated that the concentration of vanadium in soil is different between one or more of the SWMUs. However, this result does not affect the conclusions about SWMU 1, because the average concentration of vanadium at the site was less than average NASO concentration.

1.4.2 SWMU 15 – Abandoned Tank Farm

The location and history, previous investigations, extent of contamination, and results of risk assessment at SWMUs 15 – the Abandoned Tank Farm, follows.

1.4.2.1 Location and History

SWMU 15 is located in the former North Station area, approximately 800 feet northwest of Runway 23R and 1,000 feet northeast of the area used to store recreation vehicles near the old CPO club (Figure 1-2). The abandoned tank farm served as the primary source of aircraft fuel for the North Station area when it was active from the mid-1950s to the mid-1970s. The tank farm consisted of six tanks: a 414,000-gallon tank used to store JP-3, two 50,000-gallon concrete tanks used for aviation gas, and three adjacent 12,000- to 18,000-gallon tanks believed to be used for automotive fuel, kerosene, or lube oil (RGH, 1984).

According to a report by R.E. Wright Associates (1983), the tanks were emptied of fuel and filled with water after they were abandoned. Tank G-5 was later used to store waste oil. The tanks and their associated piping were dismantled and removed in the mid-1980s.

The area around SWMU 15 includes pavement, forests, shrubs, and wetlands. Old paved road surfaces and parking lots cover much of the site. In general, drainage of the site is towards the northeast. A shallow drainage ditch crosses the center of the site, bisecting a small depressional wetland, and drains south to a large emergent wetland. No outlet from the wetland has been observed. Water was observed in most of the ditch during a 1992 ecological survey, but the water did not appear to be flowing.

A large stand of mature loblolly pine occurs immediately north of the former location of the tanks and mature hardwood stands occur mainly in the eastern half of the site. The shrub communities are located along old field areas and unpaved roadbeds. The area is colonized by an early successional upland herbaceous plant community.

1.4.2.2 Previous Investigations

Previous investigations at the tank farm include: an environmental investigation in 1982, the IAS in 1984, the RCRA Facility Assessment (RFA) in 1988, the Phase I RFI in 1993, the Phase II RFI in 1995, the CMS in 1994 through 1995, and the Study of Monitored Natural Attenuation in April 2001. The following discussion summarizes the results of the previous investigations.

In 1982, free-phase product was discovered in test pits and well borings. The 1984 IAS identified the tank farm as a potential hazard. The 1988 RFA identified the tank farm as SWMU 15 and documented recommendations for additional investigation.

SWMU 15 was investigated during two phases of the RFI. Phase I was completed in 1993 (CH2M HILL, 1993) and Phase II was completed in 1995 (CH2M HILL, 1995a). The purpose of the RFIs was to characterize the extent of soil and groundwater contamination. A CMS was initiated in 1995 (CH2M HILL, 1995b) to define the extent of the groundwater contaminant plume, characterize surface soil contamination, and obtain treatability data on contaminated soil and groundwater.

Results of the investigations conducted at SWMU 15 indicated that surface soils contained elevated levels of Total Petroleum Hydrocarbon (TPH) and PAHs, and subsurface soils contain elevated concentrations of BTEX, TPH, and PAHs. Groundwater was found to contain free-phase product and elevated concentrations of BTEX, TPH, and PAHs. Vinyl chloride and isomers of 1,2-dichloroethylene were also detected at low concentrations in a few monitoring wells. The CMS recommended treatment for soil contamination and monitored natural attenuation of groundwater.

Based on recommendations from the CMS, a soil removal action was conducted at SWMU 15 in 1997 to remediate the BTEX contamination in the soil. An area measuring approximately 150 feet by 125 feet was excavated to the water table, creating a small pond. The man-made pond is located southwest of the drainage ditch. Approximately 18,000 cubic yards of soil were treated on site by bioremediation and aeration. Confirmatory soil samples were collected and a human health risk assessment was conducted on the biopile soil. The human health risk assessment of the biopile soil determined that the noncarcinogenic and carcinogenic risks for the exposure pathways evaluated in the assessment were within the USEPA's target risk levels based on residential and recreational exposure scenarios.

After the initial biological treatment, the upper 6 feet of biopile soil met criteria to be distributed as clean fill. However, the soil at the bottom 3 feet of the biopile, along with a small volume of soil in the upper 6 feet of the pile, was found to exceed the Virginia Department of Environmental Quality (VDEQ) solid waste threshold of TPH (50 mg/kg), which was the established TPH cleanup goal for the SWMU 15 soil bioremediation project. This soil was re-treated to enhance aeration and biodegradation of TPH. In October 1999, confirmatory samples (Biosystems, 1999) were collected from the re-treated biopile soils; all sample results were found to contain TPH below the VDEQ threshold of 50 mg/kg of TPH. Therefore, all the soil from the biopiles met the VDEQ criteria for clean fill.

An ecological risk assessment performed on the biopile soils involved additional surface soil sampling to determine whether or not PAHs were still a concern, and to demonstrate that PAH concentrations had decreased along with TPH concentrations in the biopile soil. In December 1999, ten additional surface soil samples were collected from the top three inches of the biopile soils remaining at SWMU 15 and from the biopile soil which had already been spread in the site restoration project at the adjacent former tarmac area. Five background surface soil samples adjacent to the tarmac restoration area were collected for comparison. All samples were analyzed for PAHs. Concentrations of the PAHs benzo(a)pyrene, benzo(k)fluoranthene, fluoranthene, and pyrene were elevated in a small portion of the samples, but when compared to equally high levels of the same PAHs in background soil

samples, these were not seen as a concern. Summing the maximum detected concentration of each PAH compound as a worst case exposure scenario (all maximum contaminant detections being co-located in a single sample) yielded a concentration of 6,736 µg/kg for total PAHs. An action level for total PAHs equal to or greater than 40,000 µg/kg was agreed to by the NAS Oceana Partnering Team. Thus, the total maximum PAH concentration, even when calculated as a worst case exposure scenario, was well below the team's agreed upon action level. The drop in PAHs and TPH was due to the re-treatment of the soil. Therefore, the ERA concluded that PAHs were not considered to be a concern in the biopile soils and no further action was necessary (CH2M HILL, March 2000). The soil was spread thinly within the tarmac restoration area to further enhance the biodegradation process.

Additional sampling at SWMU 15 include (1) confirmatory subsurface soil samples which were collected from the area around the excavation in November 1998 to evaluate the efficiency of the removal action, and (2) surface soil, sediment, and surface water samples collected in July of 1999 for use in the HHRA for the entire SWMU.

No groundwater investigation activities had been taken at SWMU 15 after the CMS until July 1999. A meeting was convened between the Navy and the EPA in June 1999 in which the EPA's office of research and development representative, Dr. John Wilson, reviewed the groundwater contamination at SWMU 15. The EPA and the Navy jointly scoped an approach to characterize groundwater contamination in a manner that would best support an assessment of monitored natural attenuation (MNA) as a viable remedial alternative. The results of this recent study are summarized in the next section. Details are provided in the April 2001 *Study of Monitored Natural Attenuation at SWMU 15.*

1.4.2.3 Contamination and Extent

This site is underlain by silts and sand in two general units. The first unit consists of silt and slightly sandy silts from the surface to 5 to 7 feet. This is underlain by clean sands and silty sands to at least 16 to 20 feet. Silt and clay is present in a unit from 20 to 26 feet.

Water level elevations collected at SWMU 15 in May 2000 show southwesterly directed groundwater flow south of the pond and a northeasterly flow north of the pond, indicating that the pond creates a mound in the water table that affects groundwater flow directions. Another round of water levels was collected in February 2001. The February 2001 water table shows south-southwesterly directed groundwater flow across the SWMU. The water table gradient flattens in the northern portion of the SWMU indicating a possible groundwater divide located north of the SWMU. Historic data showed groundwater flow to vary in direction from southwesterly to northwesterly, depending upon the season. However, the prevailing groundwater flow direction at the SWMU and at the Station is south to southwesterly.

Given the range of hydraulic conductivity of the Columbia Aquifer, groundwater would require between 200 and 2,000 years to travel beneath the runways to the flight line area of the base (to encounter human activity), or to contact a stormwater drainage ditch deep enough to intercept the water table during periods of normal precipitation. Furthermore, the Columbia Aquifer groundwater would require between 42 and 450 years to reach the residential area located 1,000 feet north of the SWMU 15 soil excavation. These travel time derivations do not account for any attenuating factors such as dilution, adsorption,

dispersion, and biodegradation. The two wells (WS-5 and WS-7) which extract groundwater from the Columbia Aquifer are located 9,000 feet and 16,000 feet away from SWMU 15.

In July 1999 the Navy installed three monitoring wells (wells MW-18, MW-20, and MW-21) near the ponded excavation at SWMU 15 to replace wells destroyed during the soil remediation process (MW-05, MW-09, and MW-15) and to place a monitoring well directly downgradient of the excavated source area (MW-19). In February 2000 the Navy began an investigation of SWMU 15 groundwater to support an assessment of MNA. The MNA study involved sampling of groundwater to determine the overall distribution of the BTEX and its degradation products and the potential for BTEX to naturally attenuate within the aquifer. An innovative approach was utilized to collect the data needed to support a monitored natural attenuation site characterization. Monitoring well sampling was conducted to determine the overall distribution of the BTEX contaminant plume. Once the highest levels of contamination were located, DPT groundwater sampling was initiated at multiple depths to determine the depth at which the maximum levels of contamination resided. Then DPT groundwater sampling was conducted on a grid array, at the depth of the highest detected contamination, to horizontally delineate the BTEX groundwater contaminant plume. At the same time, the MIP rig was used to characterize the contamination surrounding and hydraulically upgradient of the former source area, currently the ponded excavation. Discrete-depth DPT groundwater and soil sampling and hydraulic conductivity determinations were conducted at the four MIP locations to verify the results obtained during the MIP survey and vertically profile the contaminant plume.

Fourteen monitoring wells were sampled at SWMU 15 to determine the site-wide distribution of groundwater contaminants in the shallow aquifer and to provide contaminant-distribution information to direct the subsequent DPT groundwater sampling for detailed plume delineation (Figure 1-4). All the site monitoring wells are screened from 3 to 18 feet below ground surface and the samples were drawn from the middle of the screen at a depth of approximately 12 feet.

Direct push technology was used to collect groundwater samples in order to characterize the horizontal and vertical extent of the groundwater contaminant plume and the MNA parameters. A total of 45 DPT groundwater samples were collected from 30 sampling locations ranging from 5 to 25 feet below ground surface, with the most samples taken between 17-22 feet, where the highest concentrations of benzene were encountered (Figure 1-4). A truck equipped with a MIP was used at SWMU 15 to characterize the vertical distribution of volatile organic compounds and soil characteristics at four locations adjacent to the ponded excavation, which was the former source area for BTEX groundwater contamination. Discrete interval soil and groundwater samples were collected at the four MIP locations to determine contamination existing at the interface between the upper confining unit and the Columbia Aquifer, the interface between the aquifer and the lower confining unit, and at locations of highest contaminant concentrations.

Samples collected during monitoring well, DPT, and discrete depth sampling were analyzed in the close support laboratory, located on site. Groundwater samples from the fourteen monitoring wells were analyzed for TCL volatiles, including BTEX, using EPA Method 8260. The samples were also analyzed for MNA parameters including chloride, methane, ethene, ethane, ferric iron, ferrous iron, nitrate, sulfate, and sulfide.

The results of the MNA investigations determined the plume depicted in Figure 1-5. The overall shape of the plume is consistent with a predominantly south-southwesterly groundwater flow direction that intermittently shifts to a westerly to northwesterly direction during periods of heavy precipitation. The relatively flat hydraulic gradient and fluctuating groundwater flow direction might have kept the plume from migrating as far as it might have under a regime of a consistent groundwater flow direction.

Specifically, discrete-depth groundwater sampling and MIP survey results indicated that elevated BTEX constituents occur near the bottom of the Columbia Aquifer in the uppermost silt and clay layers of the basal confining unit. Some volatile hydrocarbon contamination was detected in the surficial confining unit as well. A residual NAPL is suspected in the zones of maximum contamination composed of BTEX and non-BTEX constituents of various degraded fuels. The residual NAPL, bound up in the low-permeability silt and clay, is not likely to migrate.

In the MNA study, two hypotheses were evaluated for the conceptual site model of contaminant distribution and biodegradation at SWMU 15:

- **Hypothesis 1** – NAPL is present downgradient of the excavation area and high benzene concentrations are maintained by dissolution from the NAPL to the aqueous phase.
- **Hypothesis 2** – All NAPL was removed from the site through excavation of the soils at the former tank farm area in 1996, and all of the benzene currently detected in groundwater is considered to be in a dissolved-phase plume.

The conclusions regarding the occurrence of natural attenuation at SWMU 15 are very different depending on which hypothesis is used. If NAPL is present, the aqueous concentrations of benzene and other fuel components are maintained by dissolution from the NAPL phase. A decrease in concentration consistent with natural attenuation processes would only be observed downgradient of the NAPL source zone in the dissolved-phase plume. If all of the NAPL was removed from the site during the soil excavation in 1996, then the high benzene concentrations that have been observed up to 400 feet downgradient of the excavation area suggests that benzene is not biodegrading. The following describes conclusions supporting natural attenuation of BTEX as well as conclusions supporting the alternative hypothesis that natural attenuation of benzene is not occurring at SWMU 15, respectively.

The follow conclusions support the "weight of evidence" that BTEX is naturally attenuating at this site:

- Elevated levels of benzene in groundwater appear to be caused by residual NAPL at the water table and at the base of the Columbia Aquifer, up to several hundred feet south of the former tank farm area that was excavated in 1996. The evidence for NAPL includes field observations of free product sheen on groundwater samples from wells and test pits, and benzene concentrations that are near the theoretical effective solubility for dissolved-phase benzene in contact with NAPL.
- BTEX compounds attenuate from greater than 1,000 µg/L near the edges of the apparent NAPL source area to less than 10 µg/L within 200 feet along groundwater flowpaths.

- Temporal data at well MW-07, located east of former tank G-6, indicates that benzene and xylenes decreased from 300 and 80 µg/L in 1994 to non-detect in 2000.
- Changes in electron acceptor and metabolic byproduct concentrations between the contaminated plume and reference background locations suggests that biodegradation of BTEX compounds is occurring, with iron reduction and methanogenesis being the likely dominant processes.
- The calculated first-order biodegradation rate constant for benzene ranges from 0.0006 to 0.0036 day^{-1} (half-lives of 192 to 1136 days). The average biodegradation rate is approximately 0.0023 day^{-1} (half-life of 300 days).
- Groundwater modeling simulations assuming a relatively large NAPL area and a benzene biodegradation half-life of 300 days produce simulated plumes that reasonably match the observed plume extent in the field.

The following conclusions support the alternative hypothesis that natural attenuation of benzene is not occurring at SWMU 15:

- Soil sampling performed as part of the Phase II RCRA Facility Investigation indicated that NAPL-contaminated soil was present in the former tank farm area east of former tank G-6. The contaminated soils were excavated from this area in 1996 to remove the NAPL source.
- High concentrations of benzene (ranging between 1,120 and 8,090 µg/L) are present in groundwater up to 400 feet downgradient of the excavation area. A rough estimate of the time required for the plume to travel 400 feet is approximately 20 years, which would indicate that the fuel release occurred at the end of the time period that the tank farm was active (for mid-1950's to mid-1970's).
- A well installed in 1999 (MW-20) to replace another well that was destroyed during the excavation and on-site treatment of soil in the source area (MW-15) had significantly higher benzene concentrations in February 2000 than in October 1994. The increase in benzene concentration may indicate that contaminated groundwater has migrated to the vicinity of MW-20 from the former excavated source area.
- High concentrations of methane are coincident with high benzene levels in the plume. If the methane is used as a tracer compound for the plume, the absence of high levels of methane downgradient of the benzene plume may indicate that the plume has not yet broken through to the downgradient wells.
- Groundwater modeling assuming a shallow NAPL source that is completely removed in 1996 and no biodegradation of benzene simulates a plume that is slightly smaller than what is observed in field data. The addition of a deep NAPL source near the base of the Columbia Aquifer more closely approximates the observed plume extent in the field. However, all simulations that assume no biodegradation of benzene predict a contaminant plume that spreads throughout the entire thickness of the Columbia Aquifer, which is not consistent with the vertical benzene distribution observed in the field data.

1.4.2.4 Human Health Risk Assessment

The human health risk assessment (HHRA) performed for SWMU 15 characterizes potential current and future risks to human health at the site using the general methodology described in the *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part A* (USEPA, 1989) and *RAGS, Volume 1, Human Health Evaluation Manual, Part D* (USEPA, 1998). Potential risks were calculated for a current industrial worker, current adult trespasser/visitor, current adolescent trespasser/visitor, future adult resident, future child resident, future lifetime resident, future construction worker, future industrial worker, future adult trespasser/visitor, and adolescent trespasser/visitor. Potential risks were calculated for exposure to surface soil, combined surface and subsurface soil, groundwater, and sediment.

The HHRA concludes that noncarcinogenic hazards to all potential current receptors exposed to the surface soil are below USEPA's target levels. However, carcinogenic risks for an industrial worker (2×10^{-4}) from surface soil exceeds the target risk range of acceptable excess lifetime cancer risks identified by the EPA (10^{-6} to 10^{-4}). This carcinogenic risk is primary associated with ingestion of dibenz(a,h)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene in the surface soil.

Noncarcinogenic hazards were also determined to be greater than USEPA's target HI from combined surface and subsurface soil for the future child resident scenario. The HI of 1.5 slightly exceeds USEPA's target HI of 1.0. Carcinogenic risks are also above USEPA's target risk range for exposure to surface and subsurface soils for the future industrial worker (2×10^{-4}) and residential (8×10^{-4}) scenarios. The carcinogenic risks are primarily associated with ingestion of benzo(a)pyrene, dibenz(a,h)anthracene, and benzo(b)fluoranthene in the soil. Benzo(a)pyrene and dibenz(a,h)anthracene were only detected in the surface soil samples, and benzo(b)fluoranthene was only detected in three of the subsurface soil samples. Therefore, this calculated risk is mainly associated with the surface soil, and not the subsurface soil.

In addition, the HHRA concludes future residential use of the groundwater would result in a noncarcinogenic hazard above USEPA's target HI for both a child and an adult. The hazard to the child resident is primarily associated with ingestion of arsenic, chloroform, and iron in the groundwater. The hazard to the adult is mainly associated with inhalation of chloroform, and ingestion or arsenic, chloroform, and iron. The HIs are 12 and 120, respectively. There are also carcinogenic risks above USEPA's target risk range from residential use of the groundwater. The main risk drivers causing carcinogenic risks are arsenic, benzene, and chloroform.

Noncarcinogenic hazards were found to be present for non-consumptive contact with the shallow groundwater by a future construction worker during excavation. The HI is 12. This hazard is primarily associated with inhalation of volatilized chloroform. No unacceptable risks were determined to be present from exposure to surface water or sediment in the pond.

Therefore, unacceptable risks were found to be present for an industrial worker from the surface soil under current scenarios, and to future residents and industrial workers for potential exposure from combined surface and subsurface soil. Groundwater was found to present unacceptable risks for both future residents from potable water use and a future construction worker from exposure to shallow groundwater during excavation. However, the HHRA notes that there are no industrial workers currently at the site and the site's future development by construction workers for residential purposes is highly unlikely.

Furthermore, the base's original plans to construct a hangar at SWMU 15 to provide access to Runway 23 R have since been abandoned.

1.4.2.5 Ecological Risk Assessment

The final ecological risk assessment (ERA) performed for SWMU 15 concluded that potential risks to aquatic organisms utilizing SWMU 15 are expected to be low based on the magnitude of the sediment and food web exceedences (CH2M HILL, 2001a). Potential risks to upper trophic level terrestrial organisms inhabiting SWMU 15 are low. Potential risks to lower trophic level terrestrial organisms (e.g., soil invertebrates) are relatively high based on the magnitude of the surface soil exceedences for PAHs, however, they occur in an isolated area (in surface soil adjacent to the former source area, the ponded excavation).

Based upon the results and the certainty associated with the results, the relative size of this SWMU, and the proximity of SWMU 15 to an active military runway/airfield, site specific toxicity testing or additional sampling on which to base remedial action decisions is not warranted. Therefore, no further study in the risk assessment is recommended at this time. The identified potential for risks to ecological receptors is further addressed below.

In groundwater, three metals (aluminum, iron, and manganese) and three organic chemicals (benzene, carbon disulfide, and total xylenes) had mean HQs greater than one. All groundwater HQs were relatively low (all under 3, except for iron, 22.9, and carbon disulfide, 16.1). Planned long-term monitoring of groundwater will allow confirmation that these concentrations do not increase over time. Based on groundwater modeling conducted at SWMU 15, the groundwater contamination plume resulting from the former source area has "detached" from and continues to move away from the ponded excavation; therefore, recontamination of the pond from the groundwater is unlikely. The overall shape of the benzene plume is consistent with a predominantly south-southwesterly groundwater flow direction that intermittently shifts to a westerly to northwesterly direction during periods of heavy precipitation. In addition, the residual NAPL, bound up in the low-permeability silt and clay, is not likely to migrate.

An air station-wide comparison was performed for surface soil, surface water, and sediment in order to determine whether or not concentrations of metals at SWMU 15 fell within the same range as metals across the air station. Appendix C provides the hypotheses tested and supporting data used in these comparisons. Confidence limits were calculated around the means of both the site specific and the air station-wide concentrations in order to determine whether there was evidence that the chemicals were site-related.

According to the central tendency theory, when the site confidence limits overlap with the NASO-wide confidence limits, the null hypothesis is accepted. It can be concluded with 95% confidence that the two sets of data are not statistically different (i.e., they are from the same population) and that there is no evidence of site-relatedness. Table C-2 in Appendix C shows the ranges that were calculated for each COPC at SWMU 15.

Only one chemical (aluminum) had an HQ greater than one (1.48) in surface water. This evidence shows that there is no significant migration of contaminants from the groundwater to the surface water. The mean concentration for aluminum in surface water at SWMU 15 is 128 µg/L. The air station-wide average is 715 µg/L. This comparison showed that metal concentrations in surface water at SWMU 15 are not significantly different than the air

station-wide concentrations. In addition, the screening value used for aluminum is based on dissolved metals, which are more bioavailable and therefore more toxic than total metals. Using this screening value gives a conservative estimate of risk for aluminum in surface water. Therefore, no remedial action is recommended for surface water at SWMU 15.

Cyanide had an HQ greater than one (3.12) in sediments. The average concentration of cyanide in sediments at SWMU 15 is 0.31 mg/kg. The average concentration of cyanide in sediments at NAS Oceana is 0.06 mg/kg. The confidence limit comparison showed that the cyanide concentrations in surface water at SWMU 15 are significantly different than the air station-wide concentrations. Five organic chemicals had HQs greater than one, ranging from 1.29 to 7.83. Each of these five chemicals was detected in only a small fraction of the total number of samples. For example, 2-methylnaphthalene and fluorene were only detected in one sample. There are no contamination gradients and correlation of contamination to specific sediment samples at the SWMU, and the magnitude of HQ exceedances are relatively low.

As described in Section 1.4.2.2, a soil removal action was conducted at SWMU 15 in 1997 to remediate the BTEX contamination in the soil. An area measuring approximately 150 feet by 125 feet was excavated to the water table, creating the pond at SWMU 15 (the depression from the excavation filled with water). The excavated soil was then biologically treated and used for a station restoration project. Thus, the source of contamination at SWMU 15 has been removed. The sediments in this man-made pond are not true sediments, but are the sub-surface soils that existed under the surface soils that were removed. Over time, deposition of organic material will form true sediments in the pond. These new sediments will cover the mineral soils currently at the bottom of the pond, essentially covering the organic chemicals as well. Based upon all of this evidence, no remedial action is recommended for sediments at SWMU 15.

Two PCBs had HQs exceeding one for surface soils, however they were both very low (1.20 and 1.27).

Four metals (aluminum, chromium, iron, and vanadium) had HQs greater than one (255, 42.9, 33.4, and 9.06, respectively) in soils. The soil confidence limit comparison showed that metals on SWMU 15 are within the range of basewide concentrations across the base and are not a site-specific occurrence at SWMU 15.

In addition to this parametric statistical comparison, the non-parametric Kruskal-Wallis test was performed using the soil, surface water, and sediment data to determine whether concentrations of metals at SWMU 15 fell within the same range as metals across the air station. Tables C-3 through C-5 present the results of this analysis. This comparison generally confirmed the results of the parametric comparison. The Kruskal-Wallis test indicated that concentrations of vanadium in soil, iron in surface water, and cyanide in sediment were different between one or more SWMUs. As discussed, iron in surface water was elevated at SWMU 1 and cyanide in sediment was elevated at SWMU 15. Each of these has been addressed above. As for SWMU 1, the vanadium results do not affect the conclusions about SWMU 15 because the average concentration of vanadium at SWMU 15 was less than average NASO concentration.

Therefore, no remedial action is recommended for metals at SWMU 15.

Fifteen PAHs exceeded screening values resulting in HQs ranging from 3.85 to 976, which are addressed in the remedial alternatives for this SWMU.

1.4.3 SWMU 24 – Bowser, Building 840

The location and history, previous investigations, extent of contamination, and results of risk assessment at SWMUs 24 – the Bowser, Building 840, follows.

1.4.3.1 Location and History

SWMU 24 is an area near Building 840 which contained a waste-oil bowser. Building 840 is in an industrial area of NAS Oceana, in southern portion of the station (Figure 1-2). The Naval Construction Battalion (SEABEEs) has been based in Building 840 since 1972. The SEABEEs are involved in construction at NAS Oceana and other local naval installations (USEPA, 1988). Waste solvents and oils generated at the equipment maintenance garage in Building 840 were hand carried and poured into the bowser, which was typically located in the southernmost corner of the SEABEE compound (USEPA, 1988). The bowser was then transported to the tank farm for disposal. During the visual site inspection, heavy staining of the ground was observed in the area surrounding the waste oil bowser at Building 840 (USEPA, 1988). Current practice is to dispose of waste oil in drums that are transported to the base hazardous waste lot, where they are disposed or recycled appropriately. The bowsers are no longer used. The site consists of a fenced gravel area surrounded by a perimeter of brush, forest, and mowed lawn. There is limited wildlife habitat in the immediate area of SWMU 24. Wildlife inhabits the forested areas surrounding SWMU 24.

1.4.3.2 Previous Investigations

Environmental problems at SWMU 24 were first recognized during the RFA in 1988 when oil staining was observed in surface soil surrounding a used oil bowser. Subsequent investigations at SWMU 24 include: the Phase I RFI in 1993, the Phase II RFI in 1995, the Phase III RFI in 1997, a POL-CMS (CH2M HILL, 1994), and a CMS for groundwater in 1995 (CH2M HILL, 1996), and DPT and groundwater sampling in 1998 (CH2M HILL, 1998).

The Phase I RFI (CH2M HILL, 1993) was conducted to delineate the source area and the extent of POL-contaminated soil. Soil sampling results indicated that the SWMU should be characterized for soil removal. The POL-CMS (CH2M HILL, 1994) delineated the soils for removal at SWMU 24. The USEPA requested additional confirmatory sampling at SWMU 24 after reviewing the POL-CMS and the *Excavation, Transportation and Disposal of Petroleum Contaminated Soils* report (ENSCI Env. Inc., 1995). After excavation of the contaminated soils in 1994, confirmatory subsurface soil sampling was performed at SWMU 24 in 1997, as part of the Phase III RFI, to confirm that the POL soil removal was effective (CH2M HILL, 1997).

During the POL CMS (CH2M HILL, 1994), groundwater contamination was discovered. The SWMU was added to the 1995 Phase II RFI scope of work to address groundwater contamination. CH2M HILL conducted the CMS for groundwater in 1995 (CH2M HILL, 1996). Results of the investigations indicated that groundwater at SWMU 24 is contaminated with chlorinated VOCs and BTEX. Vinyl chloride, 1,2-dichloroethelene, and trichloroethene were detected at the SWMU.

In late 1996 and early 1997, an in-well aeration pilot study (*NoVOCs*) was initiated at SWMU 24. Contaminant concentrations in the source area were dramatically reduced using in-well aeration (CH2M HILL, 1997). The estimated mass reduction of *cis*-1,2-DCE ranged from 22-76 percent. However, some outlying areas of the contaminant plume were not treated and the need for additional remediation was investigated further.

A direct push technology (DPT) investigation was conducted in November 1998 to determine the boundaries of the *cis*-1,2-DCE groundwater plume at SWMU 24 and to assess the overall effectiveness of the NoVOCs remediation pilot study (CH2M HILL, 2000b). Monitoring wells were also sampled as part of this investigation.

1.4.3.3 Contamination and Extent

Geologic cross sections indicate that the top of the Yorktown aquifer is approximately 25 feet below the ground surface. A clayey-silt unit underlies the southern portion of the SWMU in the vicinity of 24-MW7. Geologic cross sections of SWMU 24 are shown in excerpts from the CMS presented in Appendix A. The results of the most recent groundwater sampling are summarized in the next section and the entire *Final Technical Memorandum for the Groundwater Sampling at SWMU 24* is presented in Appendix D.

Water levels measured during the November 1998 groundwater sampling indicate groundwater flow directions to the south and southwest across the site.

The extent of contamination present at SWMU 24 was determined through monitoring well and DPT groundwater sampling conducted in November 1998 in the area where the No VOCs groundwater remediation was conducted in 1996. A total of fourteen wells and piezometers were sampled and a total of 113 direct push samples were collected from 40 locations at depths of 8 feet (shallow), 14 feet (intermediate), and 20 feet (deep). Well, piezometer, and DPT sample locations are depicted in Figure 1-6. The direct push sampling determined *cis*-1,2-DCE, TCE, and benzene concentrations exceeded federal maximum contaminant levels (MCLs) and EPA Region III Risk Based Concentrations (RBCs) for tap water. Both *cis*-1,2-DCE and TCE were detected at several sample locations in the study area. Benzene was detected at only one sample location.

The residual groundwater contamination was found to exist hydraulically downgradient of the NoVOCs treatment well. *cis*-1,2-DCE was found at highest concentrations at 8 feet below ground surface with concentrations ranging from 3.4 µg/L to 588 µg/L. TCE was found at highest concentrations at 14 feet below ground surface with concentrations ranging from 0.25 to 27 µg/L. When direct push samples were averaged, geometrically, over depths of 8 feet, 14 feet, and 20 feet, the highest area of DCE contamination, at sample location GW-48, is only slightly above the MCL of 70 µg/L (72.6 µg/L). No TCE concentrations exceeded the MCL (5 µg/L) when averaged over the three sampling depths in the shallow aquifer. Therefore, results of the direct push sampling suggest the presence of a localized *cis*-1,2-DCE hot spot near PZ3 and GW-48 that has a limited areal and vertical extent.

Concurrent with the direct push investigation, groundwater samples were collected from the twelve shallow monitoring wells (MW01, MW1D, MW02, MW03, MW04, MW05, MW06, MW07, MW08, MW09 MW10 and MW11), one shallow piezometer (PZ3S), and one deep piezometer (PZ3D) at SWMU-24 using standard low-flow groundwater sampling techniques. The sampling confirmed that contamination includes chlorinated VOCs, specifically *cis*-1,2-

DCE, TCE, and vinyl chloride, at concentrations that exceed MCLs and RBCs for tap water. Iron and manganese also exceed the RBCs for tap water and arsenic exceeds both the RBC and MCL. Lead exceeded the MCL at one sample location. Refer to the technical memorandum included as Appendix D for locations of regulatory exceedances.

According to the EPA guidance document *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (September 1998), anaerobic biological activity from the degradation of chlorinated solvents of fuel hydrocarbons often solubilizes arsenic and manganese from the aquifer matrix material. Similarly, the presence of Iron (II) may indicate an anaerobic degradation process due to the depletion of oxygen and nitrate, and the reduction of Iron (III) to Iron (II). Therefore, the occurrence of these metals at concentrations above background levels, particularly in the area where the NoVOCs study was implemented, may be attributed to the biodegradation of *cis*-1,2-DCE.

The primary transport mechanism from sources at SWMU 24 was identified as leaching from the soil to the groundwater. The contaminated soil is no longer present, therefore, all that remains is the residual contamination in the Columbia Aquifer groundwater. Based on groundwater monitoring, the groundwater plume does not appear to be migrating significantly and is biodegrading at a rate equivalent to the rate of contaminant migration. Risks from the contamination present at SWMU 24 are determined in the HHRA.

1.4.3.4 Human Health Risk Assessment

The human health risk assessment (HHRA) performed for SWMU 24 characterizes potential current and future risks to human health at the site using the general methodology described in the *Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual, Part A* (USEPA, 1989) and *RAGS, Volume 1, Human Health Evaluation Manual, Part D* (USEPA, 1998). Potential risks were calculated for a future adult resident, future child resident, future lifetime resident, and future construction worker. Surface soil, subsurface soil, and groundwater were all contaminated by operations at SWMU 24. The contaminated soil was removed in 1997, therefore, the only remaining source of contamination at SWMU 24 is the residual contamination in the groundwater.

The HHRA found noncarcinogenic hazards associated with use of the groundwater as a potable residential water supply above USEPA's target noncarcinogenic HI of 1.0 for both the child and adult resident. The HIs are 31 and 13, respectively. The hazards are primarily associated with ingestion of arsenic, *cis*-1,2-dichloroethene, iron, and manganese in the groundwater. There are also carcinogenic risks associated with use of the groundwater as a potable residential water supply above USEPA's target risk range of $1x10^{-4}$ to $1x10^{-6}$. The residential lifetime carcinogenic risk is $2x10^{-3}$. The main risk driver is arsenic. There were no unacceptable risks from non-consumptive contact with groundwater for a construction worker during excavation into the shallow water table aquifer.

Therefore, unacceptable risks were determined to be present to a future resident for potential exposure from groundwater. The HHRA concludes the only potential scenario resulting in hazards or risks above USEPA's target level is future residential use of the site, a scenario which is highly unlikely.

1.4.3.5 Ecological Risk Assessment

A Screening Ecological Risk Assessment was prepared for SWMU 24 (CH2M HILL, October 1999) which proposes no further action for ecological concerns at the SWMU due to lack of complete exposure pathways. Groundwater at the SWMU does not discharge to surface water. Contaminated soils at SWMU 24 were removed and confirmatory sampling showed that the removal action was successful.

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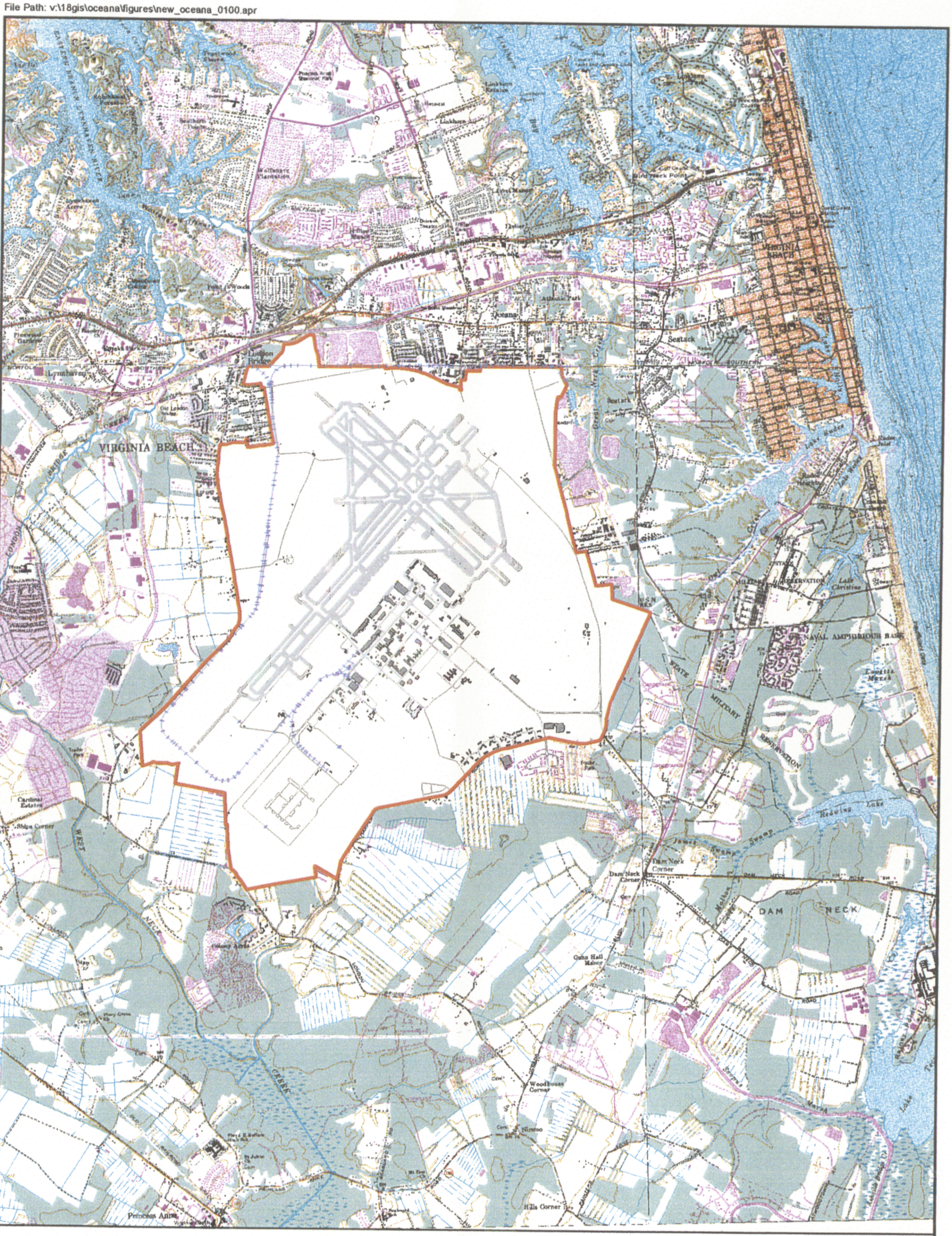

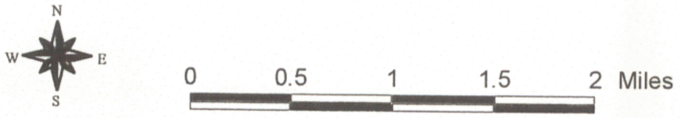

Figure 1-1
Base Location Map
NAS Oceana, Virginia Beach, Virginia

CH2MHILL

00557 E B1y

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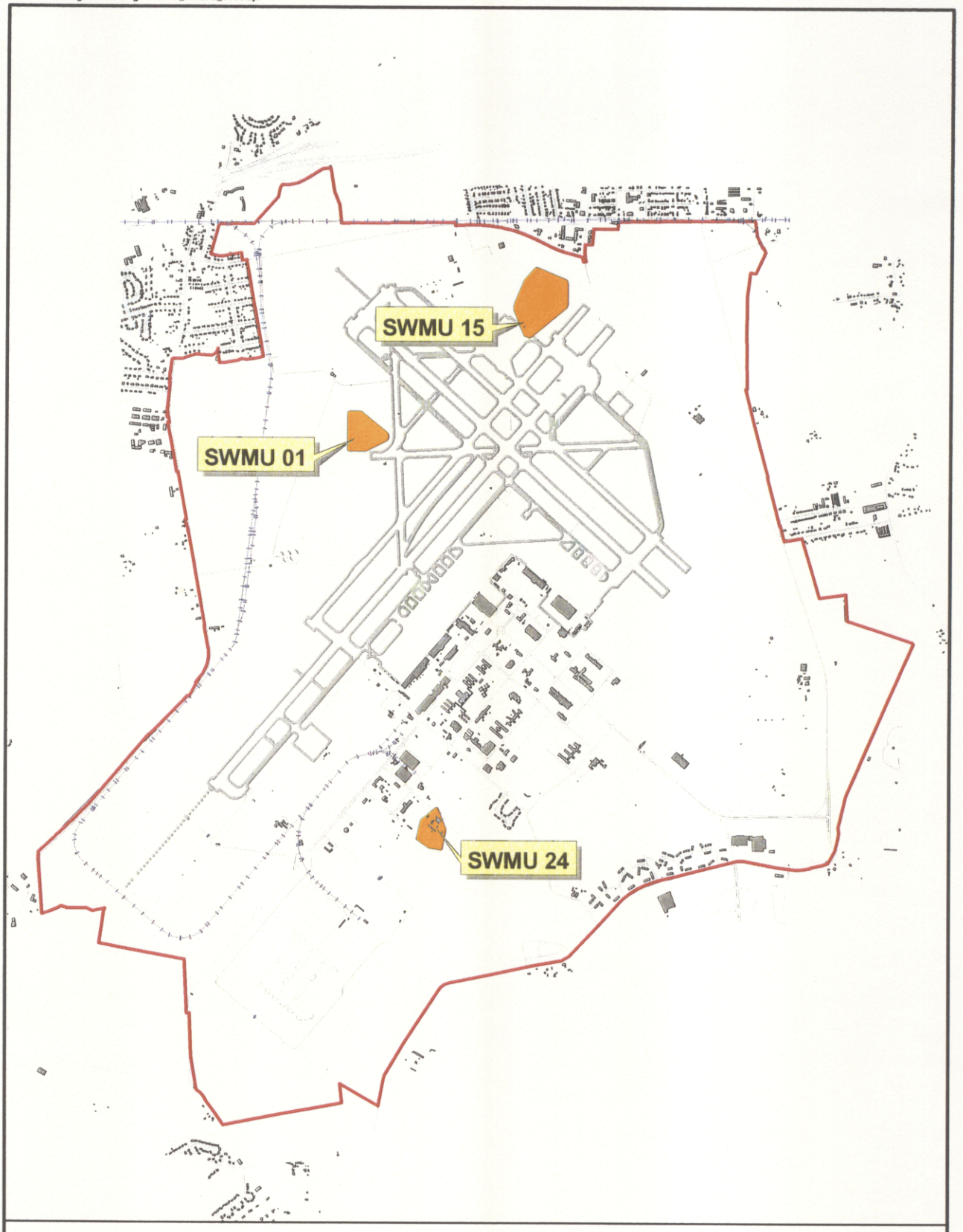
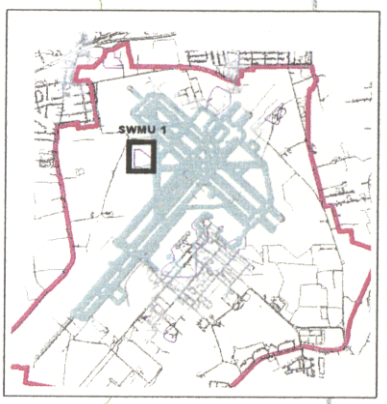


Figure 1-2
SWMU 1, 15, & 24 Location Map
NAS Oceana, Virginia Beach, Virginia

CH2MHILL

File Path: v:\18gis\oceana\new_oceana_11_29_00.apr



1-MW10
1-MW8
1-MW8D
1-PZ5
1-PZ4
1-MW2
1-PZ3
1-MW4
1-PZ1
1-MW7D
1-MW5
1-MW9D
1-MW1
1-MW7
1-PZ2
1-MW3
1-MW6

Monitoring Wells

N
W E
S

0 90 180 270 Feet

Figure 1-3
Location Map with Monitoring Wells - SWMU 1
NAS Oceana, Virginia Beach, Virginia

CH2MHILL

File Path: V:\18gis\Oceana\swmu-15_mna.apr

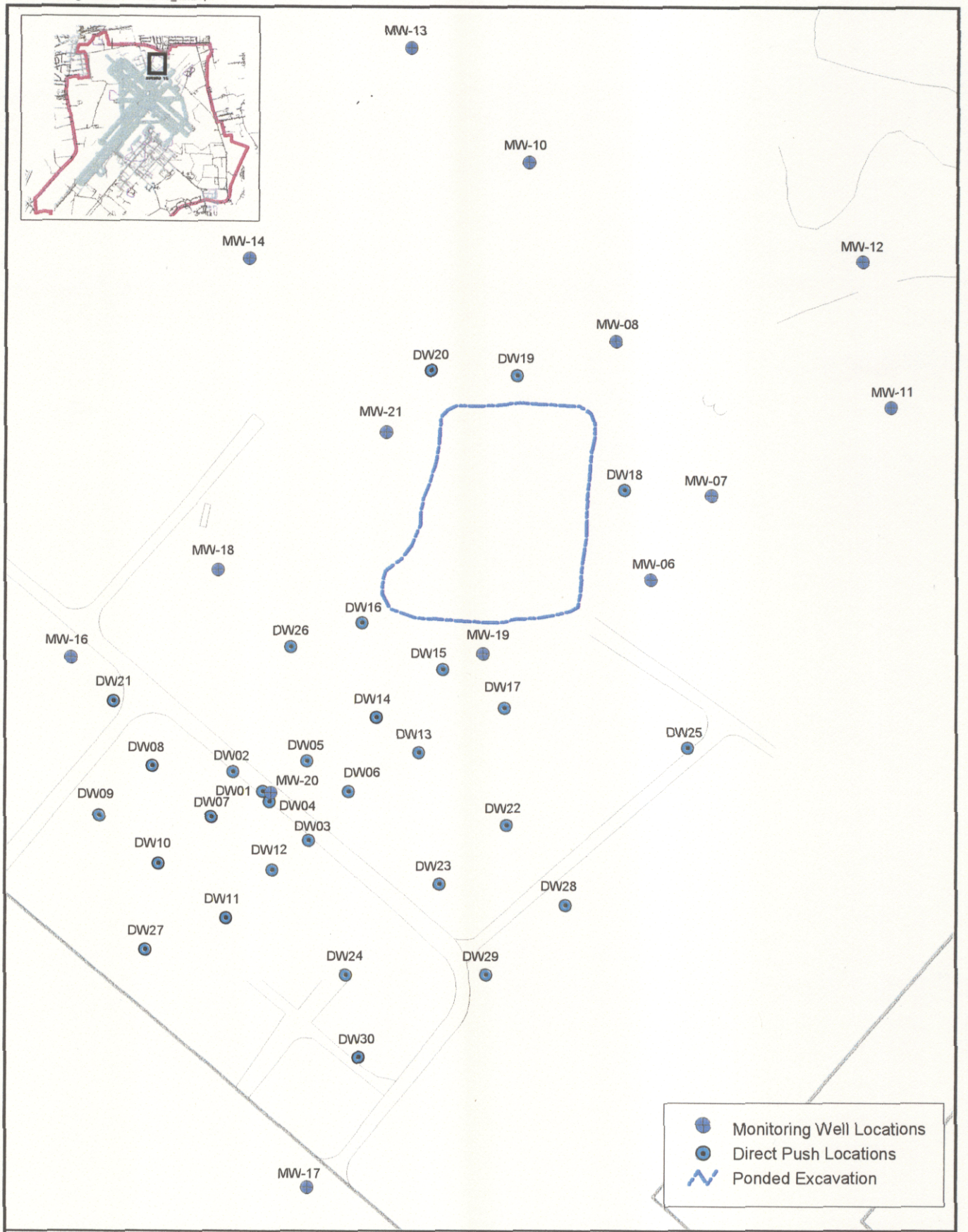
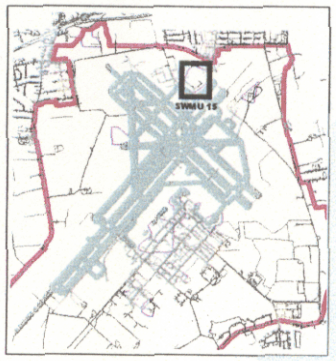


Figure 1-4
Monitoring Well & DPT Groundwater Sampling Locations - SWMU 15
NAS Oceana, Virginia Beach, Virginia

CH2MHILL

File Path: v:\18gis\oceana\swmu-15_mna.apr



MIP-02
DW20
DW19
MIP-01
DW18
MIP-04
DW16
DW26
MIP-03
DW15
DW21
DW17
DW14
DW13
DW25
DW08
DW02
DW05
DW01
DW06
DW09
DW07
DW04
DW22
DW03
DW10
DW12
DW23
DW28
DW11
DW27
DW24
DW29
DW30

Ponded Excavation
MIP/VP Locations
Direct Push Locations
Total BTEX
1 ug/L
100 ug/L
1000 ug/L
2000 ug/L
3000 ug/L
4000 ug/L
5000 ug/L
6000 ug/L
7000 ug/L
8000 ug/L
9000 ug/L
10000 ug/L

Groundwater samples were collected from DPT screen intervals of 15-20, 17-22, or 20-25 feet below ground surface depending upon topography. MIP samples are from depths between 22 and 25 feet with the highest BTEX concentrations.

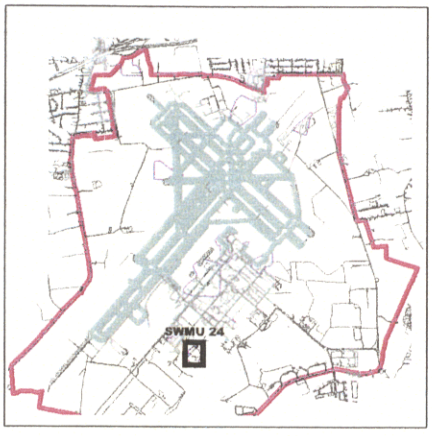
N
W
E
S

0 100 200 300 Feet

Figure 1-5
Total BTEX in Groundwater - SWMU 15
NAS Oceana, Virginia Beach, Virginia

CH2MHILL

File Path: v:\18gis\oceana\new_oceana_11_29_00.apr



24-MW11
24-MW10
24-MW5
24-MW6
24-GW51
24-GW46
24-GW35
24-GW32
24-MW1D
24-MW1
24-GW01
24-MW4
24-GW18
24-GW02
24-GW03
24-GW19
24-GW17
24-GW04
24-GW05
24-GW20
24-GW15
24-GW06
24-GW07
24-GW21
24-GW14
24-GW48
24-MW3
24-GW31
24-GW13
24-GW08
24-GW09
24-GW30
24-GW12
24-GW10
24-GW23
24-GW29
24-MW2
24-GW28
24-GW11
24-GW24
24-GW36
24-GW27
24-GW25
24-GW43
24-GW42
24-GW38
24-GW26
24-GW47
24-GW41
24-MW9
24-MW8
24-MW7

Monitoring Well Locations
DPT Groundwater Sample Locations - 1998

N
W
E
S

0 50 100 150 Feet

Figure 1-6
Location Map with Monitoring Wells and DPT Locations - SWMU 24
NAS Oceana, Virginia Beach, Virginia

CH2MHILL

2.0 Remedial Action Objectives and ARARs

This section presents general and site-specific remedial action objectives (RAOs) and identifies corresponding applicable or relevant and appropriate requirements (ARARs) for SWMUs 1, 15, and 24. General RAOs are defined by the NCP and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (as amended by the Superfund Amendments and Reauthorization Act [SARA]), which are applicable to all Superfund sites. CERCLA defines the statutory requirements for developing remedies.

Site-specific RAOs relate to specific contaminated media and to potential exposure routes. Site-specific RAOs, which require an understanding of the contaminants and the physical properties in their respective media, are based on an evaluation of the risks to public health and to the environment and the ARARs.

2.1 NCP and CERCLA Objectives

The NCP requires that the selected remedy meet the following objectives:

- Each remedial action selected shall be protective of human health and the environment [40 CFR 300.430 (f)(ii)(A)].
- Onsite remedial actions that are selected must attain those applicable or relevant and appropriate requirements (ARARs) that are identified at the time of the Record of Decision (ROD) signature [40 CFR 300.430(f)(ii)(B)].
- Each remedial action selected shall be cost effective. A remedy shall be cost effective if its costs are proportional to its overall effectiveness [40 CFR 300.430 (f)(ii)(D)].
- Each remedial action shall use permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable [40 CFR 300.430 (f)(ii)(E)].

The statutory scope of CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) to include the following general objectives for remedial action at all CERCLA sites:

- Remedial actions "shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a minimum which assures protection of human health and the environment" (Section 121(d)).
- Remedial actions "in which treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element" (Section 121(b)) are preferred. If the treatment or recovery technologies selected are not a permanent solution, an explanation must be published.

- The least-favored remedial actions are those that include "offsite transport and disposal of hazardous substances or contaminated materials without treatment where practicable treatment technologies are available" (Section 121(b)).

The selected remedy must comply with or attain the level of any "standard, requirement, criteria, or limitation under any federal environmental law, or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation" (Section 121(d)(2)(A)).

2.2 Development of Site Specific Remedial Action Objectives (SWMUs 1, 15, and 24)

Both the level of contamination and the potential exposure routes are considered when developing site-specific RAOs for protecting public health and the environment. The future protection of environmental resources and the means of minimizing long-term disruption to existing facility operations are also considered.

2.2.1 Site-Specific Remedial Action Objectives

Site-specific RAOs for SWMUs 1, 15, and 24 are documented below.

2.2.1.1 SWMU 1

The HHRA, summarized in Section 1.4.1.4, concluded that no unacceptable risk is posed by current conditions in the soil at SWMU 1. Potential risks were identified from the residential use of groundwater at the SWMU. Groundwater from the water-table (Columbia) aquifer and the deeper Yorktown aquifer is not currently a source of drinking water. The impact of any leaching of contaminants from the waste-oil pit would be greatest in the shallow water-table aquifer. Due to the presence of a clay confining unit between the shallow and deeper aquifers, contamination that may have leached from the waste-oil pit has not reached the Yorktown aquifer. This is substantiated by sampling of the Yorktown Aquifer with deep wells at SWMU 1 which yielded non-detects for contaminants of concern.

The final ecological risk assessment (ERA) performed for SWMU 1 concluded that potential risks to soil invertebrates utilizing SWMU 1 are expected to be low to moderate but occur only in an isolated area. The few COPCs that pose a risk in surface soil were generally consistent with background soil concentrations. No COPC exceeded both a screening value and an upgradient concentration in surface water or sediment. No HQ for food web exposures for either terrestrial or aquatic receptors exceeded one based on a LOAEL. Considering the relatively low habitat value of these ditches (which are periodically maintained as part of the stormwater system) and the likelihood that upper trophic level receptors would forage elsewhere (where habitat quality was better) much of the time, risks to these species are likely to be negligible.

The site-specific RAO for SWMU 1 is as follows:

- Prevent unacceptable risks to potential human receptors to the groundwater

2.2.1.2 SWMU 15

The HHRA, summarized in Section 1.4.2.4, concluded that unacceptable risk to industrial workers and to ecological receptors is posed by current conditions in the surface soil at SWMU 15. Potential risks also were identified from future residential and industrial use of the soil and from the residential use of groundwater at the SWMU. Additionally, if the site were to be excavated by construction workers, the construction workers would be subject to unacceptable risks from contact with shallow groundwater during excavation.

Groundwater from the water-table (Columbia) aquifer and the deeper Yorktown aquifer is not currently a source of drinking water. The impact of any leaching of contaminants from the abandoned tank farm would be greatest in the shallow water-table aquifer. Due to the presence of a clay confining unit between the shallow and deeper aquifers, it is not likely that any contamination that may have leached from the tank farm has reached the Yorktown aquifer.

The final ecological risk assessment (ERA) performed for SWMU 15 concluded that potential risks to aquatic organisms utilizing SWMU 15 are expected to be low based on the magnitude of the sediment and food web exceedances (CH2M HILL, 2001a). Potential risks to upper trophic level terrestrial organisms utilizing SWMU 15 are low. Potential risks to lower trophic level terrestrial organisms (e.g., soil invertebrates) are relatively high based on the magnitude of the surface soil exceedances for PAHs; however, they occur in an isolated area (in surface soil adjacent to the former source area, the ponded excavation).

The site-specific RAOs for SWMU 15 are as follows:

- Minimize direct contact of human receptors with surface soil that may pose unacceptable risks
- Minimize direct contact of ecological receptors with surface soil that may pose unacceptable risks
- Prevent unacceptable risks to potential human receptors to the groundwater (consumptive and non-consumptive)

2.2.1.3 SWMU 24

The HHRA, summarized in Section 1.4.3.4, concluded that due to the soil removal action, soil is not a media of concern at SWMU 24. Potential risks were identified from the potable use of groundwater at the SWMU. Groundwater from the water-table (Columbia) aquifer and the deeper Yorktown aquifer is not currently a source of drinking water. The impact of any leaching of contaminants from the bowser area would be greatest in the shallow water-table aquifer. Due to the presence of a clay confining unit between the shallow and deeper aquifers, it is not likely that any contamination that may have leached from the bowser area has reached the Yorktown aquifer.

The Final ERA performed for SWMU 24 concluded that no further action is necessary at the SWMU based on ecological concerns due to lack of complete exposure pathways.

The site-specific RAOs for SWMU 24 is as follows:

- Prevent unacceptable risks to potential human receptors to the groundwater

2.2.2 Applicable or Relevant and Appropriate Requirements

As required by Section 121 of CERCLA, remedial actions carried out under Section 104 or secured under Section 106 must attain the levels of standards of control for hazardous substances, pollutants, or contaminants specified by the ARARs of federal and state environmental laws and state facility-siting laws, unless waivers are obtained. According to US EPA guidance, remedial actions also must be based on nonpromulgated "to-be-considered" criteria or guidelines if the ARARs do not address a particular situation.

ARARs are distinguished by the USEPA as either being applicable to a situation or relevant and appropriate to it. These distinctions are critical to understanding the constraints imposed on remedial alternatives by environmental regulations other than CERCLA. The definitions of ARARs below are from the US EPA guidance (EPA 1988a).

"Applicable requirements" are standards and other environmental protection requirements of federal or state law dealing with a hazardous substance, pollutant, or contaminant and its remedial action. For example, the Clean Water Act (CWA) is "applicable" to a response action for discharging treated effluent.

"Relevant and appropriate requirements" are standards and environmental protection criteria of federal or state law that, although not "applicable" to a hazardous substance or remedial action, address situations sufficiently similar to those at the CERCLA site that their use is suitable. For example, although RCRA regulations are not applicable to closing a site containing hazardous waste that was disposed of before 1980, the regulations may be relevant and appropriate.

A requirement may be "relevant" to a particular situation but not "appropriate" because of differences in the duration of the regulated activity or the physical characteristics of the affected media. For example, some of the requirements for designing and operating a waste pile that are found in 40 CFR 264.251, such as using a liner of sufficient strength and thickness to prevent failure caused by pressure gradients, might be considered relevant and appropriate, although the requirement to install a liner to cover all surrounding earth in potential contact with the waste might not be appropriate if the earth already is contaminated, and the eventual remedy is to remove all the contaminated earth.

A requirement that is relevant and appropriate must be met as if it were applicable. Relevant and appropriate requirements that are more stringent than applicable requirements, take precedence. However, more discretion is allowed in determining relevant and appropriate requirements than in determining applicable requirements.

Another factor in determining which response or remedial requirements must be met is whether the requirement is substantive or administrative. Onsite CERCLA response actions must meet substantive requirements but not administrative requirements. Substantive requirements are those dealing directly with actions or with conditions in the environment. Administrative requirements implement the substantive requirements by prescribing procedures such as fees, permitting, and inspection that make substantive requirements effective. This distinction applies to onsite actions only; offsite response actions are subject to all applicable standards and regulations, including administrative requirements such as permits.

2.2.3 Other Criteria or Guidelines To Be Considered

Many federal and state programs have criteria, advisories, guidelines, and proposed standards that provide recommended procedures if no ARARs exist or if existing ARARs are inadequate. In such situations, the "to-be-considered" criteria or guidelines should be used to set remedial action levels. Examples of criteria to be considered are reference doses and potency factors for ingestion of noncarcinogenic and carcinogenic compounds used in the risk assessment.

2.2.4 Determination of ARARs

Federal and state ARARs for SWMUs 1, 15, and 24 are summarized in Appendix E. The tables summarize the potential ARARs by classification and the "to-be-considered" criteria are included as appropriate for each classification. There are three classifications of ARARs: chemical-specific, location-specific, and action-specific, as further described in this section.

The remedial action alternatives developed in this FS were analyzed for compliance with the potential federal and state ARARs. This analysis involved identifying potential requirements for each of the alternatives, evaluating their applicability or relevance, and determining if the remedial alternatives can achieve the ARARs. Results of that analysis are presented in Section 4.2.

2.2.5 Chemical-Specific Requirements

Examples of federal chemical-specific requirements include RCRA toxicity characteristics, SDWA MCLs and MCL goals, air quality standards, and ambient water quality criteria. Chemical-specific ARARs are not available for soil. Instead, site-specific risk-based PRGs (to-be-considered criteria) have been developed for soil, and groundwater where applicable, for evaluation of the remedial alternatives. The ARARs and PRGs will serve as screening levels for any confirmatory sampling to evaluate the efficacy of the chosen remedial alternative.

Potential chemical-specific requirements for the site are presented in Section 2.3.

2.2.6 Location-Specific Requirements

Location-specific requirements are design requirements or activity restrictions that are based on the geographic position of a site. An example is RCRA location requirements that set US EPA policy for carrying out provisions of Executive Order 11988 (Flood Plain Management) and Executive Order 11990 (Protection of Wetlands). Other location-specific requirements pertain to protection of critical wildlife habitats (Endangered Species Act), wilderness areas (Wilderness Act), and wildlife refuges (USC 668). Potential location-specific requirements for the site are presented in Appendix E.

2.2.7 Action-Specific Requirements

Action-specific requirements set performance, design, or other standards for particular activities in managing hazardous substances or pollutants. Potential action-specific requirements include state and federal air pollution regulations. These requirements are applicable to any site remediation activities that may generate air discharges. This and other action-specific requirements for the site are presented in Appendix E.

2.3 Development of Risk-Based Preliminary Remediation Goals

Preliminary remediation goals (PRGs) were developed from ARARs and other available information, such as concentrations associated with 10^{-6} cancer risk or a hazard quotient equal to one for non-carcinogens calculated from EPA toxicity information. PRGs were established for each contaminant of concern in surface soil and groundwater. Risk-based PRGs were calculated for groundwater when chemical-specific ARARs (MCLs) were not available. Risk-based PRGs are "to-be-considered" criteria, not ARARs. No chemical-specific ARARs are available for soil. The following discusses the methodology that was used to calculate the risk-based PRGs.

Risk-based PRGs were calculated for the residential scenario with carcinogenic risks exceeding 10^{-4} or noncarcinogenic hazards exceeding 1. PRGs were calculated for individual constituents with carcinogenic risks exceeding 10^{-6} or noncarcinogenic hazards exceeding 0.1 for the scenarios that exceed the above criteria.

Although the three SWMUs are currently used for mainly industrial purposes, and anticipated future use of the SWMUs is for industrial purposes, risk-based PRGs were developed for potential future residential receptors. The exposure parameters identified in the HHRA were used to calculate the risk-based PRGs for the residential receptors.

Appendix F provides the equations and exposure parameters used to calculate the risk-based PRGs, and the resulting risk-based PRGs. The target noncarcinogenic HQ for the risk-based PRGs for each constituent was determined based on the number of constituents that result in an effect to the same target (i.e., nervous system). The target HQ for each constituent was chosen so that the total hazard to the receptor would be below 1. Therefore, if two constituents effect the same target, the target noncarcinogenic hazard for those constituents would be 0.5. The target carcinogenic risk level for the risk-based PRGs was selected based on the number of carcinogenic constituents, and chosen so that the total carcinogenic risk to a receptor would be below 10^{-4}.

2.3.1 SWMU 1 Groundwater

Napthalene is a chemical of concern in groundwater at SWMU 1. As there is no chemical-specific ARAR (MCL) for napthalene, the risk-based PRG was calculated for the residential scenario, as presented in Table 2-1. The maximum detected concentration of napthalene is greater than its calculated risk-based PRG.

2.3.2 SWMU 15 Surface Soil

As there are no ARARs for contaminants in soil, risk-based PRGs were calculated for constituents with concentrations exceeding background concentrations in the surface soils adjacent to the pond area (samples OW15-SS06 through OW15-SS09). The contaminants of concern are arsenic, and PAHs, particularly, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

PRGs were developed for potential receptors based on the residential scenario. The exposure parameters identified in the HHRA were used to calculate the PRGs.

Appendix F provides the equations and exposure parameters used to calculate the PRGs, and the resulting PRGs. PRGs were calculated based on hazard quotients (HQs) of 0.1, 0.5, and 1, and carcinogenic risks of 10^{-6}, 10^{-5}, and 10^{-4}. The HQ and carcinogenic risk level for the recommended PRGs were selected based on the number of noncarcinogenic constituents effecting a particular target organ and the number of carcinogenic constituents, as discussed below. Exposure to only one of the PAHs of potential concern results in noncarcinogenic health effects. Therefore, the recommended PRG for this constituent (fluorene) is based on a HQ of 1. The remaining six PAHs of potential concern are all carcinogenic (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene). Therefore, to keep the risk from exposure to all of the constituents below $1x10^{-4}$, the individual recommended PRGs are based on a risk of $1x10^{-5}$.

Table 2-2 summarizes the recommended PRGs that were developed for the contaminants of concern.

The maximum concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene exceed their respective recommended PRGs (at sample locations OW15-SS06 and OW15-SS07).

The cleanup goal for protection of ecological receptors from total PAHs is 40 mg/kg (CH2M HILL, 2000c).

The individual human health risk-based PRGs for select PAHs will need to be met from implementation of the selected alternative to be protective of human health, and the total PAH cleanup goal will need to be met from implementation of the selected alternative to be protective of ecological receptors.

2.3.3 SWMU 15 Groundwater

Benzene, chloroform, methylene chloride, napthalene, arsenic, iron, and manganese are chemicals of concern in groundwater at SWMU 15. As there are no chemical-specific ARARs (MCLs) for methylene chloride, napthalene, iron, and manganese, risk-based PRGs were calculated for the residential scenario for these constituents, as presented in Table 2-3. The maximum detected concentrations of all chemicals of concern exceed their respective MCLs or calculated risk-based PRGs, with the exception of napthalene.

2.3.4 SWMU 24 Groundwater

Cis-1,2-dichloroethene, arsenic, iron, and manganese are chemicals of concern in groundwater at SWMU 24. As there are no chemical-specific ARARs (MCLs) for iron and manganese, risk-based PRGs were calculated for the residential scenario for these constituents, as presented in Table 2-4. The maximum detected concentrations of all chemicals of concern exceed their respective MCLs or calculated risk-based PRGs.

Table 2-1
Preliminary Remediation Goals
Groundwater
SWMU 1, NAS Oceana

Chemicals of Concern	Maximum Detected Concentration (ug/L)	Residential Scenario Risk-Based PRG[1] (ug/L)	Maximum Contaminant Level[2] (ug/L)
SVOCs			
Naphthalene	208	1.7E-01	-

Notes:

1. Risk-based Preliminary Remediation Goals (PRGs) were calculated when ARARs (MCLs) were not available.
2. USEPA, Summer 2000
3. Shaded cell indicates maximum concentration detected is above risk-based PRG.

Table 2-2
Preliminary Remediation Goals
Soil Ingestion, Dermal Contact, and Inhalation (Human Health) and Ecological Risk
SWMU 15, NAS Oceana

Chemicals of Concern	Maximum Detected Concentration (mg/kg)	Human Health Residential Scenario Risk-Based PRG (mg/kg)	Basis	Ecological PRG (mg/kg)
Inorganics				
Arsenic	2	3.4	Lifetime, CR = 10^{-5}	N/A
SVOCs				
Benzo(a)anthracene	23	8.7	Lifetime, CR = 10^{-5}	N/A
Benzo(a)pyrene	29	0.87	Lifetime, CR = 10^{-5}	N/A
Benzo(b)fluoranthene	49	8.7	Lifetime, CR = 10^{-5}	N/A
Benzo(k)fluoranthene	16	87	Lifetime, CR = 10^{-5}	N/A
Dibenzo(a,h)anthracene	34	0.87	Lifetime, CR = 10^{-5}	N/A
Indeno(1,2,3-cd)pyrene	16	8.7	Lifetime, CR = 10^{-5}	N/A
Total PAHs	2,323	N/A	N/A	40

Notes (Human Health PRGs):
1. Child scenario selected for noncarcinogenic PRGs since child scenario more conservative (lower PRGs).
2. For constituents with basis of CR = 10^{-5}, PRG for CR =10^{-5} less than PRG for applicable HQ.
3. Used CR of 10^{-5} to keep overall carcinogenic risk below 10^{-4}.
4. Applicable HQ chosen to keep total HI for each target organ below 1.
5. Shaded cell indicates maximum concentration detected is above risk-based PRG.

Notes (Ecological PRG):
1. Reference: Final SWMU 15 Biological Soil Remediation Project Closeout Report and Confirmatory Soil Sampling Technical Memorandum, Oceana Naval Air Station, Virginia Beach, Virginia, March 2000, and Technical Memorandum - Ecological Evaluation of the SWMU 15 Biopile Soils, Naval Air Station, Oceana, Virginia Beach, Virginia, March 2000.
2. Shaded cell indicates maximum concentration detected is above the PRG.

Table 2-3
Preliminary Remediation Goals
Groundwater
SWMU 15, NAS Oceana

Chemicals of Concern	Maximum Detected Concentration (ug/L)	Residential Scenario Risk-Based PRG[1] (ug/L)	Maximum Contaminant Level[2] (ug/L)
VOCs			
Benzene	3444	--	5
Chloroform	278	--	80
Methylene Chloride	216	86	-
SVOCs			
Naphthalene	28	170	-
Inorganics			
Arsenic [3]	19.6	--	10
Iron	15400	15000	-
Manganese	490	310	-

Notes:

1. Risk-based Preliminary Remediation Goals (PRGs) were calculated when ARARs (MCLs) were not available.
2. USEPA, Summer 2000
3. 66 FR 6976, January 22, 2001 (for the arsenic MCL)
4. Shaded cell indicates maximum concentration detected is above risk-based PRG or MCL.

Table 2-4
Preliminary Remediation Goals
Groundwater
SWMU 24, NAS Oceana

Chemicals of Concern	Maximum Detected Concentration (ug/L)	Residential Scenario Risk-Based PRG[1] (ug/L)	Maximum Contaminant Level[2] (ug/L)
VOCs			
cis-1,2-Dichloroethene	500	--	70
Inorganics			
Arsenic [3]	224	--	10
Iron	69300	2300	-
Manganese	743	310	-

Notes:

1. Risk-based Preliminary Remediation Goals (PRGs) were calculated when ARARs (MCLs) were not available.
2. USEPA, Summer 2000
3. 66 FR 6976, January 22, 2001 (for the arsenic MCL)
4. Shaded cell indicates maximum concentration detected is above risk-based PRG or MCL.

3.0 Development of Remedial Alternatives

This section discusses the remedial alternatives developed to address the remedial action objectives (RAOs) for contamination present at SWMUs 1, 15, and 24.

3.1 General Response Actions

General response actions are broad classes of responses, remedies, or technologies developed to meet the site-specific RAOs. Each general response action is intended to address specific contaminants and the possible migration pathways and exposure routes in each environmental medium. Although an action may be capable of meeting the objective for a given medium, combinations of actions may later prove to be more cost effective in meeting all the objectives for the site. Therefore, to comply with the site RAOs, the general response actions are normally combined to form site-wide remedial alternatives.

The general response actions listed below have been identified for the remediation of SWMUs 1, 15, and 24:

- No Action
- Institutional Control Actions
- Monitoring Actions
- Treatment Actions
- Collection Actions

Under the *no action response,* the current site conditions at each SWMU would remain. The NCP requires that a no action alternative be developed as a baseline for evaluating remedial alternatives.

Institutional control actions consist of a number of alternatives that can be used singly or as part of a site-wide remedial alternative. Institutional controls include such activities as installing fences, placing warning signs, or applying restrictions to the land use or activities affecting the use of groundwater.

Monitoring actions include long-term monitoring, monitoring active remediation, or monitoring natural attenuation. Long-term monitoring consists of tracking groundwater quality and the potential for offsite plume migration. Remediation or attenuation of contaminants could also monitored by collecting groundwater samples.

Treatment actions include technologies that prevent the direct contact with surface soil and groundwater that may pose unacceptable risks. These technologies include remediation actions such as enhanced biodegradation, in-situ soil treatment, and air stripping technologies (such as *NoVOCs*) for groundwater treatment.

Collection actions involve pumping wells to extract contaminated groundwater, or free-product collection through the use of skimmers.

The above general response actions have been used to create a range of site-wide alternatives that can be compared on cost and compliance with the site-specific RAOs.

3.2 Identification and Screening of Remedial Technologies

Remedial technologies were identified which could meet the RAOs for each SWMU. These technologies were then screened using site-specific information from previous investigations to determine the feasibility of each technology, and eliminate technologies that could not be implemented effectively.

3.2.1 SWMU 1

Table 3-1 presents the identification and screening of remedial technologies for SWMU 1. The discussion below presents the technologies that passed the initial screening.

No Action

The no action response is retained to serve as a baseline for evaluating remedial alternatives.

Institutional Controls

The institutional controls retained during the screening process consists of restrictions on use of the groundwater. The effectiveness of access restrictions depends on continued use and the ability to enforce them.

Monitoring

The monitoring action that was not eliminated is long-term monitoring. Groundwater monitoring can be protective of human health by identifying any changes in the extent of contamination and any further degradation of groundwater quality either in conjunction with or independent of active remediation.

Free-Product Collection

An option retained through the screening of remedial technologies is the continued operation of the solar-powered positive-displacement pulsed skimmer pumps at 1-MW4, 1-MW5, 1-PZ3, and 1-PZ5 for the removal of any free product. The recovery scenarios that incorporate a constant-rate single-pump system or a constant-rate dual-pump system would not be cost-effective based upon the results of performance tests conducted at SWMU 1 that indicated that the free-product contamination is not easily recoverable by pumping systems. Free product could be removed until the product thickness is less than 0.01 feet for three consecutive months.

Treatment

Oil/water separation, carbon adsorption, and in-situ biological treatment through an Oxygen Releasing Compound (ORC) were the only treatment processes retained after the screening. An oil/water separator could be used to separate the free-phase product from the groundwater. Carbon adsorption could be used to treat dissolved fuel constituents. Any extracted groundwater could be treated to reduce TPH contamination to the discharge requirements. However, it is not anticipated that a large volume of contaminated groundwater will be generated because the collection of free product will be designed to minimize

the extraction of groundwater. The use of in-situ biological treatment to enhance biodegradation could be an effective way to reduce contamination at SWMU 1.

Discharge

As large volumes of groundwater will not be extracted for treatment, no discharge option of treated groundwater was retained through the screening. All free product and groundwater removed from the skimmers in 1-MW4, 1-MW5, 1-PZ3, 1-PZ5 could be contained in the skimmer tanks for inclusion in the NAS Oceana hazardous-waste stream with subsequent offsite treatment and disposal.

Free-Product Disposal

Any free product collected can be disposed of at a permitted offsite facility. The material can be managed with other NAS Oceana waste oil collection activities.

3.2.2 SWMU 15

Tables 3-2 and 3-3 present the identification and screening of remedial technologies for SWMU 15 groundwater and soil, respectively. The discussion below presents the technologies that passed the initial screenings for groundwater and soil.

3.2.2.1 SWMU 15 Groundwater

No Action

The no action response is retained to serve as a baseline for evaluating remedial alternatives.

Institutional Controls

The institutional controls retained during the screening process consists of groundwater use and excavation restrictions (to prevent non-consumptive contact of groundwater to a construction worker). The effectiveness of institutional controls depends on continued use and the ability to enforce them. Institutional controls can be used as a stand-alone alternative but also will likely be a part of any other alternative.

Monitoring

The monitoring actions that were not eliminated include long-term monitoring, monitoring active remediation, and monitoring natural attenuation.

Natural attenuation would involve monitoring the natural processes that retard the transport of, and degrade contaminants in the groundwater, to show that the extent of the contaminant plume will, under natural conditions, reach equilibrium and then dissipate. Natural attenuation modeling and monitoring has been shown to be an acceptable method for addressing petroleum contamination in aquifers where no current or near-term future exposure risks exist.

Long term groundwater monitoring can be protective of human health by identifying any changes in the extent of contamination and any further degradation of groundwater quality. At SWMU 15, petroleum contaminants have been present for 20 to 40 years without substantial migration.

Treatment

Treatment processes not eliminated from screening include *in situ* technologies. A potential technology for *in situ* treatment includes the use of ORC to promote aerobic biodegradation.

3.2.2.2 SWMU 15 Soil

No Action

The no action response is retained to serve as a baseline for evaluating remedial alternatives.

Treatment

The treatment processes not eliminated from screening includes *in situ* landfarming, which has been implemented effectively at other similarly contaminated sites at the facility.

3.2.3 SWMU 24

Table 3-4 presents the identification and screening of remedial technologies for SWMU 24. The discussion below presents the technologies that passed the initial screening.

No Action

The no action response is retained to serve as a baseline for evaluating remedial alternatives.

Institutional Controls

The institutional control retained during the screening process consists of groundwater use restrictions. The effectiveness of institutional controls depends on continued use and the ability to enforce them.

Institutional controls can be used as a stand-alone alternative but will also likely be a part of any other alternative.

Monitoring

The monitoring action that was not eliminated is long-term monitoring. Groundwater monitoring can be protective of human health by identifying any changes in the extent of contamination and any further degradation of groundwater quality either in conjunction with or independent of active remediation. Unlike petroleum hydrocarbons, chlorinated compounds have not been shown to be amenable to rapid degradation; however, natural attenuation of the contaminants is expected because the groundwater contamination at SWMU 24 consists of very low concentrations of chlorinated hydrocarbons which may become diluted to concentrations below cleanup levels before reaching downgradient monitoring wells.

Treatment

Treatment processes not eliminated from screening include *in situ* technologies. A potential technology for *ex situ* treatment includes the use of ORC to promote aerobic biodegradation.

3.3 Remedial Alternatives for SWMU 1

3.3.1 Site-Specific Remedial Action Objectives

The site-specific RAO for SWMU 1 is as follows:

- Prevent unacceptable risks to potential human receptors to the groundwater

3.3.2 Remedial Alternatives

Several remedial alternatives were developed for SWMU 1 on the basis of the general response actions and the results of the screening of remedial technologies. The alternatives identified for detailed evaluation include the following:

- Alternative 1 – No Action
- Alternative 2 – Free-Product Removal, Institutional Controls, and Long-Term Monitoring
- Alternative 3 – Use of ORC, Free-Product Removal, Institutional Controls, and Long-Term Monitoring

The major components of each remedial alternative are defined in the following subsections.

3.3.2.1 Alternative 1 – No Action

The no action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no action alternative. Under this alternative, no controls or remedial technologies would be implemented. CERCLA (Section 121(c)), as amended by SARA (1986), requires that the site be reviewed every 5 years since contamination (i.e. groundwater) would remain onsite.

3.3.2.2 Alternative 2 – Free-Product Removal, Institutional Controls, and Long-Term Monitoring

Alternative 2 consists of administrative measures (groundwater-use restrictions) with long-term monitoring conducted to track groundwater quality and the potential for offsite plume migration, along with continued use of skimmers to remove any free product from the water table. The major components of this alternative are discussed below.

Free-Product Removal

As mentioned in section 1.4.1.2, the Navy installed two solar-powered skimmers in 1997, which began recovering the free phase petroleum product found in 1-MW4, 1-MW5, 1-PZ3, and 1-PZ5. These skimmers are presently in use and free-product removal will continue under this alternative until less than 0.01 feet of free product is recoverable from the existing wells at the SWMU for three consecutive months. The Navy would continue to maintain and monitor the skimmers on a regular basis.

Institutional Controls

Institutional controls at SWMU 1 would include restrictions on future residential use of the groundwater within the site boundaries and within some distance downgradient of the site boundaries.

Long-Term Monitoring

The Navy will prepare a long-term monitoring plan, using the 1998 groundwater data collected at SWMU 1 as a baseline, to detail the procedure for periodic long-term monitoring of napthalene at the SWMU. The following discussion is a preliminary plan for the long-term monitoring at SWMU 1.

Long-term monitoring at SWMU 1 would begin upon implementation of the long-term monitoring plan. Groundwater samples would be collected from the wells shown in Figure 1-3. Initially, sampling will be conducted for five consecutive quarters. The 5th quarter sampling event will begin the annual sampling. Each annual sampling event will occur in a different quarter to account for seasonal fluctuation (i.e., 5th quarter sampling event will be conducted during the 1st quarter of the year, the next annual sampling event would be conducted in the 2nd quarter of the second year, the next event would be conducted in the 3rd quarter of the third year). Each existing well will be sampled, and all samples will be analyzed for full suite Target Analyte List (TAL)/Target Compound List (TCL) analyses.

After the 5th quarter of sampling, the first annual groundwater report will be produced. The report will document a trends evaluation and groundwater level/flow. During the 2nd, 3rd, and 4th years, streamlined groundwater monitoring reports will be produced, presenting the analytical data as well as qualitative general trends in the analytical data.

After the 5th year sampling event, another report will be produced, with the same level of detail as the 5th quarter report. Based on all the analytical results, the sampling and analysis scheme will be evaluated and potentially modified during the 5-year site review for the subsequent annual sampling events.

3.3.2.3 Alternative 3 – Use of ORC, Free-Product Removal, Institutional Controls, and Long-Term Monitoring

Alternative 3 consists of the use of an Oxygen Releasing Compound (ORC) to enhance biodegradation and reduce contaminant levels, in addition to the administrative measures, free-product removal, and long-term monitoring included in Alternative 2. The major components of this alternative are discussed below.

Oxygen Releasing Compound (ORC)

ORC is a substance that when introduced to an aquifer, slowly releases oxygen and enhances the degradation of a contaminant. ORC is a proprietary formulation of magnesium peroxide, designed to provide a timed release of oxygen. ORC is manufactured as a powder, which can be mixed with water for slurry injection into the saturated zone.

During the first year, a pilot study will be conducted, consisting of injecting ORC in a representative portion of the contaminant plume and monitoring groundwater quality in and downgradient of this pilot treatment zone over a 4- to 8-month period. This testing program would be initiated to confirm general project feasibility and design parameters prior to proceeding with a full-scale implementation. Specifically, measurements of degradation rates, the zone of influence of the ORC, the migration pathways of the ORC, the ORC volume required, the estimated efficiency of ORC use at SWMU 24, and the approximate clean up time required would be determined. During this period, monitoring of field redox parameters (dissolved oxygen, oxidation reduction potential [ORP], pH, and

ferrous iron), biochemical oxygen demand (5-day), chemical oxygen demand, and SVOCs (including napthalene) will be conducted every month from select wells within the treatment area, upgradient, and downgradient of the treatment area. Based upon the result of the pilot study, a final design of an ORC injection system would be developed. The following is a discussion of a preliminary design of a system, which may need to be redeveloped based on the results of the pilot study.

A 'grid' approach would be utilized for the full-scale ORC injection via a network of direct-push injection points. It is assumed that ORC would be applied using direct push hydraulic equipment. Drive rods would be pushed to the bottom of the contaminated saturated zone in areas with contaminant concentrations greater than the risk-based PRG and then an ORC/water slurry would be injected as the rods are withdrawn. The ORC would be used for at least 6 months. For the full scale, after application, samples would be collected every other month for a 6- to 8-month period to validate the enhancement of biodegradation processes from all wells within the treatment area, upgradient, and downgradient of the treatment area. It is assumed that four additional wells would need to be installed either upgradient and/or downgradient of the treatment area. Samples would be analyzed for the same parameters as during the pilot test. It is assumed that two re-applications of ORC would be required (during a second and third year), although each re-application would likely be done over a reduced area and dose amount compared to the initial application. After the initial biodegradation and geochemical trends have been identified (first application), the monitoring frequency would be decreased to an annual program.

Free-Product Removal, Institutional Controls, and Long-Term Monitoring

Free-product removal is currently being implemented. The institutional controls and long-term monitoring will occur as discussed under Alternative 2. The long-term monitoring program would begin after the ORC pilot test and full-scale applications (5th year).

3.4 Remedial Alternatives for SWMU 15

3.4.1 Site-Specific Remedial Action Objectives

The site-specific RAOs for SWMU 15 are as follows:

- Minimize direct contact of human receptors with surface soil that may pose unacceptable risks
- Minimize direct contact of ecological receptors with surface soil that may pose unacceptable risks
- Prevent unacceptable risks to potential human receptors to the groundwater (consumptive and non-consumptive)

3.4.2 Remedial Alternatives

Several remedial alternatives were developed for SWMU 15 on the basis of the general response actions and the results of the screening of remedial technologies. The alternatives identified for detailed evaluation include the following:

- Alternative 1 – No Action

- Alternative 2 –Monitored Natural Attenuation, Institutional Controls, In-situ Soil Landfarming
- Alternative 3 –Long-Term Monitoring, Institutional Controls, In-situ Soil Landfarming
- Alternative 4 – Downgradient Reactive Curtain of ORC, Long-Term Monitoring, Institutional Controls, In-situ Soil Landfarming

The major components of each remedial alternative are defined in the following subsections.

3.4.2.1 Alternative 1 – No Action

The no action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no action alternative. Under this alternative, no controls or remedial technologies would be implemented. CERCLA (Section 121(c)), as amended by SARA (1986), requires that the site be reviewed every 5 years since contamination (i.e. soil and groundwater) would remain onsite.

3.4.2.2 Alternative 2 – Monitored Natural Attenuation, Institutional Controls, In-situ Soil Landfarming

Alternative 2 consists of groundwater sampling to monitor the natural attenuation of contaminants, with administrative measures to restrict groundwater use, and in-situ landfarming of surface soil to reduce elevated PAH concentrations around the ponded area. The major components of this alternative are discussed below.

Monitored Natural Attenuation

Natural attenuation may be considered for contamination that is easily biodegradable or otherwise may naturally be reduced to concentrations below ARARs. Natural processes such as biodegradation, dilution, volatilization, and adsorption to aquifer soils can remove the risk to humans from contaminated groundwater. Because the main contaminant of concern at SWMU 15 is a volatile petroleum hydrocarbon (benzene), the contamination at SWMU 15 a good candidate for evaluation of attenuation through naturally occurring biodegradation and volatilization. Natural attenuation may be able to stabilize the contaminant plume, thereby preventing offsite migration to any potential receptors, primarily through biodegradation.

A monitored natural attenuation study was conducted at SWMU 15 in 2001. In the MNA study, two hypotheses were evaluated for the conceptual site model of contaminant distribution and biodegradation at SWMU 15:

- **Hypothesis 1** – NAPL is present downgradient of the excavation area and high benzene concentrations are maintained by dissolution from the NAPL to the aqueous phase.
- **Hypothesis 2** – All NAPL was removed from the site through excavation of the soils at the former tank farm area in 1996, and all of the benzene currently detected in groundwater is considered to be in a dissolved-phase plume.

The conclusions regarding the occurrence of natural attenuation at SWMU 15 are very different depending on which hypothesis is used. If NAPL is present, the aqueous concentrations of benzene and other fuel components are maintained by dissolution from the

NAPL phase. A decrease in concentration consistent with natural attenuation processes would only be observed downgradient of the NAPL source zone in the dissolved-phase plume. If all of the NAPL was removed from the site during the soil excavation in 1996, then the high benzene concentrations that have been observed up to 400 feet downgradient of the excavation area suggests that benzene is not biodegrading.

As described in the April 2001 MNA report as well as in Section 1.4.2.3 of this FS, field data was collected and evaluated to determine the potential for natural attenuation at SWMU 15. While various conclusions supported the "weight of evidence" that BTEX is naturally attenuating at this site, other conclusions supported the alternate hypothesis that benzene is not naturally attenuating at this site, while the remaining components (TEX) are attenuating. Additional data is required to more effectively characterize the natural attenuation process. As part of this alternative, additional soil sampling will be conducted to confirm the presence or absence of NAPL outside of the area that was excavated in 1996, and to specifically delineate the downgradient edge of the NAPL. Confirmational soil sampling would be performed at both shallow (water table) and deeper depths near the bottom of the Columbia Aquifer. A MIP rig would be used to characterize the contamination at approximately 20 locations (to a depth of 25 feet below ground surface) within and downgradient of the benzene hot spot. From approximately ten locations, samples will be collected from the water table smear zone as well as from a select depth below ground surface based on the MIP results. The samples would be analyzed for TPH (diesel range organics and gasoline range organics).

Also as part of this alternative, long-term monitoring of natural attenuation will be conducted by installing permanent monitoring wells, strategically placed along three flow paths within the contaminated zone (wells would be placed based on the results of the soil characterization). The Navy's MNA guidance documents recommend that several closely-spaced monitoring wells be installed along the axis of the plume to facilitate plume tracking. The following locations are proposed for installing long-term monitoring wells for natural attenuation monitoring along each flow path:

- At an uncontaminated upgradient location,
- Within the hotspot,
- At the downgradient edge of the NAPL source zone, and
- Within the downgradient dissolved-phase plume.

In addition "sentinel" wells would be installed in uncontaminated groundwater locations along each flow path further downgradient of the dissolved-phase plume to verify that the contamination is not spreading.

The monitoring wells include nested, or "cluster" wells, which are screened at the water table (screened from 3 feet to 11 feet below ground surface) and near the bottom of the Columbia Aquifer (screened from 17 feet to 22 feet below ground surface). Short screened intervals will be used to lessen the mixing of groundwater from different vertical zones of the aquifer.

The locations of the proposed soil and groundwater sampling to confirm the presence or absence of NAPL outside of the excavation area, as well as the proposed locations of monitoring wells for long-term monitoring of natural attenuation are shown on Figure 3-1.

The actual soil characterization/sampling locations and placement of the monitoring wells may be altered based on the collected field data.

MNA of the groundwater at SWMU 15 would involve annual groundwater sampling from all the wells in the MNA network in order to assess the rate at which biodegradation of BTEX is occurring. The frequency of groundwater sampling is considered appropriate due to the slow groundwater velocity. The groundwater will be sampled for Low Concentration Volatiles (including BTEX), and other MNA parameters such as ferrous iron, ferric iron, chloride, nitrate, nitrite, sulfate, methane, ethane, and ethene. Field parameters such as dissolved oxygen, temperature, pH, conductivity, and redox potential will also be collected. The detailed schedule of monitoring and parameters to be sampled for would be documented in the SWMU 15 MNA section of the Long-Term Monitoring Plan for NAS Oceana.

An MNA evaluation will be performed after 5 years of monitoring to confirm contaminant biodegradation rates, re-evaluate the data collected, and document lines of evidence for MNA. The models will be run again using new information to modify model inputs to match site conditions more closely, to more accurately determine the time necessary to achieve remediation goals, and determine the length of time appropriate for the monitoring activities to continue.

Institutional Controls

Institutional controls at SWMU 15 would include restrictions on future residential use of the groundwater within the site boundaries and within some distance downgradient of the site boundaries. Restrictions also would be placed on activities that would involve excavations into the shallow water table aquifer that would cause non-consumptive contact with the groundwater.

In-situ Soil Landfarming

As mentioned in sections 1.4.2.4 and 1.4.2.5, unacceptable risks were found to be present to an industrial worker and ecological receptors under current soil conditions at the SWMU. The HHRA notes that there are no industrial workers currently at the site and the site's future development for residential purposes is highly unlikely, however, the in-situ remediation of the contaminated soil performed under this alternative would mitigate potential current risks from surface soil. As determined during sampling, elevated concentrations of PAHs occur along the southern and eastern boundaries of the man-made pond created after the initial soil excavation at SWMU 15 (Figure 3-2). Similar to the biological re-treatment which was performed for the bottom 3 feet of the biopile (Section 1.4.2.2), the soil in these areas will be treated through landfarming. Landfarming enhances the naturally occurring biological processes of indigenous microorganisms (typically bacteria) to degrade organic contaminants by providing oxygen to increase the rate of degradation of the contaminants.

Landfarming would be conducted at SWMU 15 by aerating (tilling) the soil regularly to allow oxygen to permeate the soil. Microbes in the soil then aerobically decompose the organic contaminants. The tilling will be performed using a tractor or other agricultural equipment to encourage aeration of the soil down to 2 feet below ground surface. Tilling will occur in the spring so that the warmth of the summer months would enhance biodegradation of hydrocarbons. The areal extent over which the tilling will occur is

depicted in Figure 3-2. After 2 months, ten composite surface soil samples will be taken to confirm a reduction of PAH concentrations. If results are found to be below the human health and ecological PRGs developed in Section 2.3.2, no further action will be necessary for soil remediation. However, if results still exceed the PRGs, an additional 2-month period of tilling, aeration, and possibly the addition of other nutrients such as water or nitrogen, will be necessary, followed by another confirmatory surface soil sampling event.

3.4.2.3 Alternative 3 – Long-Term Monitoring, Institutional Controls, In-situ Soil Landfarming

Alternative 3 consists of administrative measures (groundwater-use restrictions) with long-term monitoring to track groundwater quality and the potential for offsite plume migration. The major components of this alternative are discussed below.

Long-Term Monitoring

Long-term monitoring at SWMU 15 would be conducted to track groundwater quality and the potential for offsite plume migration. The Navy will prepare a long-term monitoring plan, using the 2000 groundwater data collected at SWMU 15 as a baseline, to detail the procedure for periodic long-term monitoring of benzene at the SWMU. The following discussion is a preliminary plan for the long-term monitoring at SWMU 15.

Groundwater samples would be collected annually from the newly installed wells described under Alternative 2 (shown on Figure 3-3). Initially, sampling will be conducted for five consecutive quarters. The 5th quarter sampling event will begin the annual sampling. Each annual sampling event will occur in a different quarter to account for seasonal fluctuation (i.e., 5th quarter sampling event will be conducted during the 1st quarter of the year, the next annual sampling event would be conducted in the 2nd quarter of the second year, the next event would be conducted in the 3rd quarter of the third year). Each well (existing and newly installed) will be sampled, and all samples will be analyzed for full suite Target Analyte List (TAL)/Target Compound List (TCL) analyses.

Groundwater modeling will be performed to estimate the time to cleanup (TTCU) for the remaining contaminants of concern at SWMU 1 after the 5th quarter of sampling, at which point the first annual groundwater report will be produced. The report will document the results of the TTCU modeling, trends evaluation, and groundwater level/flow. During the 2nd, 3rd, and 4th years, streamlined groundwater monitoring reports will be produced, presenting the analytical data as well as qualitative general trends in the analytical data.

After the 5th year sampling event, another report will be produced, with the same level of detail as the 5th quarter report. Based on all the analytical results, the sampling and analysis scheme will be evaluated and potentially modified during the 5-year site review for the subsequent annual sampling events.

Institutional Controls and In-situ Soil Landfarming

The administrative measures to prevent groundwater use will be the same as included in Alternative 2.

3.4.2.4 Alternative 4 – Downgradient Reactive Curtain of ORC, Long-term Monitoring, Institutional Controls, In-situ Soil Landfarming

Alternative 4 consists of the use of a downgradient reactive curtain of Oxygen Releasing Compound (ORC) to enhance biodegradation of contaminants, with the administrative

measures and *in-situ* landfarming of surface soil discussed in Alternative 2. The major components of this alternative are discussed below.

Downgradient Reactive Curtain of Oxygen Releasing Compound

ORC is a substance that when introduced to an aquifer, slowly releases oxygen and enhances the degradation of a contaminant. ORC has been successfully applied to BTEX plumes in a wide range of conditions. A pilot study would need to be performed for the final design of an ORC injection system at SWMU 15. The pilot study would involve injecting ORC in select locations and measuring the changes in oxygen, and contaminant concentrations over 4 to 8 months. Measurements of degradation rates of contaminants, the zone of influence of the ORC, the migration pathways of the ORC, the demand factor of the ORC, and soil permeability would be determined. Based upon the result of the pilot study, a final design of an ORC injection system would be developed. The following is a discussion of a preliminary design of a system, which may need to be redeveloped based on the results of the pilot study.

The application of a downgradient reactive curtain of ORC was modeled in the April 2001 MNA report. The model simulated the effect of an oxygenated reactive curtain of ORC on the benzene plume. The ORC would be injected at the location shown on Figure 3-4. The effect of the curtain would be to induce strongly aerobic conditions, resulting in aerobic biodegradation of benzene. The reactive curtain was represented in the model as a 10-foot wide zone reaching from the water table to the bottom of the Columbia Aquifer.

The initial concentrations for the model run (time zero) were obtained from the model simulation assuming a shallow and deep NAPL source and no biodegradation (Figure 3-5). The interaction of the benzene plume with a reactive curtain is shown at 5, 15, and 30 years in Figures 3-6 through 3-8. These figures present the simulated benzene concentrations in both the shallow and deep portions of the Columbia Aquifer. At 5 years (Figure 3-6), the location of the reactive curtain is apparent as the plume is bifurcated with the primary source concentrations prevented from moving downgradient past the curtain, and the residual downgradient edge of the plume continuing to migrate to the southwest. It should be noted that the location of the reactive curtain was selected to prevent the migration of the highest concentrations of contaminants associated with the source areas from moving downgradient. However, if migration of the relatively low concentrations associated with the downgradient portion of the dissolved benzene plume is of concern, the reactive curtain could simply be relocated further downgradient to capture the remainder of the plume. The simulated benzene concentrations at later times are shown on Figures 3-7 and 3-8. It is apparent from these figures that the reactive curtain is predicted to be effective at preventing the downgradient migration of source zone contamination while the down-gradient detached portion of the plume continues to migrate to the south and west.

Model simulations showed that a reactive ORC curtain may be effective at preventing the downgradient migration of a contaminant plume. Additional field data, such as evaluation of aerobic biodegradation rates in ORC treatment zones, would need to be collected during the pilot study to evaluate the site-specific effectiveness of the technology.

Long-term monitoring (as described in Alternative 3) will be necessary to monitor the effectiveness of the ORC curtain in preventing offsite migration of the benzene plume as well as the remaining contaminants of concern. Based on results of sampling at these wells,

the duration necessary to achieve PRGs will be determined. Groundwater samples collected from wells just upgradient and downgradient of the ORC curtain will also be sampled for biodegradation parameters such as ferric iron, ferrous iron, chloride, nitrate, nitrite, sulfate, methane, ethane, and ethene, and field parameters such as dissolved oxygen, temperature, pH, conductivity, and redox potential. Based on results of sampling at these wells, the duration of ORC re-injection can be better determined.

Institutional Controls and In-situ Soil Landfarming

The administrative measures to prevent groundwater use will be the same as included in Alternative 2. The *in-situ* landfarming of the surface soil around the pond will be completed before the ORC system is implemented and direct push injection is performed around the perimeter of the pond.

3.5 Remedial Alternatives for SWMU 24

3.5.1 Site-Specific Remedial Action Objectives

The site-specific RAO for SWMU 24 is as follows:

- Prevent unacceptable risks to potential human receptors to the groundwater

3.5.2 Remedial Alternatives

Several remedial alternatives were developed for SWMU 24 on the basis of the general response actions and the results of the screening of remedial technologies. The alternatives identified for detailed evaluation include the following:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls, and Long-Term Monitoring
- Alternative 3 – Use of ORC, Institutional Controls, and Long-Term Monitoring

The major components of each remedial alternative are defined in the following subsections.

3.5.2.1 Alternative 1 – No Action

The no action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no action alternative. Under this alternative, no controls or remedial technologies would be implemented. CERCLA (Section 121(c)), as amended by SARA (1986), requires that the site be reviewed every 5 years since contamination (i.e. groundwater) would remain onsite.

3.5.2.2 Alternative 2 – Institutional Controls, and Long-Term Monitoring

Alternative 2 consists of administrative measures (groundwater-use restrictions) with long-term monitoring conducted to track groundwater quality and the potential for offsite plume migration. The major components of this alternative are discussed below.

Institutional Controls

Institutional controls at SWMU 24 would include restrictions on the use of groundwater as a potable residential water supply within the site boundaries and within some distance downgradient of the site boundaries.

Long-Term Monitoring

The Navy will prepare a long-term monitoring plan, using the 1998 groundwater data collected at SWMU 24 as a baseline, to detail the procedure for periodic long-term monitoring of *cis*-1,2-DCE, arsenic, iron, and manganese at the SWMU. The following discussion is a preliminary plan for the long-term monitoring at SWMU 24.

Long-term monitoring at SWMU 24 would involve the installation of two new wells, and the sampling of the twelve existing wells, to track groundwater quality and the potential for offsite plume migration. Due to the slow groundwater velocity, groundwater samples would be collected annually from the wells shown in Figure 3-9. Two new wells will be installed and screened from 5 to 15 feet bgs: one well in the hot spot area around PZ 3S and one well south of GW13 and west of GW12, in order to detect any plume migration to the south. The twelve existing wells at SWMU 24 also will be sampled to detect any plume migration.

As DCE degrades, inorganics such as arsenic and manganese often solubilize from the aquifer material. After 3 years of DCE degradation, the arsenic and manganese is expected to have precipitated out of solution or become sorbed onto aquifer material. Initially, sampling will be conducted for five consecutive quarters. The 5th quarter sampling event will begin the annual sampling. Each annual sampling event will occur in a different quarter to account for seasonal fluctuation (i.e., 5th quarter sampling event will be conducted during the 1st quarter of the year, the next annual sampling event would be conducted in the 2nd quarter of the second year, the next event would be conducted in the 3rd quarter of the third year). Each well (existing and newly installed) will be sampled, and all samples will be analyzed for full suite Target Analyte List (TAL)/Target Compound List (TCL) analyses.

After the 5th quarter of sampling, the first annual groundwater report will be produced. The report will document a trends evaluation, and groundwater level/flow. During the 2nd, 3rd, and 4th years, streamlined groundwater monitoring reports will be produced, presenting the analytical data as well as qualitative general trends in the analytical data.

After the 5th year sampling event, another report will be produced, with the same level of detail as the 5th quarter report. Based on all the analytical results, the sampling and analysis scheme will be evaluated and potentially modified during the 5-year site review for the subsequent annual sampling events.

3.5.2.3 Alternative 3 – Use of ORC, Institutional Controls, and Long-Term Monitoring

Alternative 3 consists of the use of ORC to enhance biodegradation of contaminants, with the administrative measures and long-term monitoring discussed in Alternative 2. The major components of this alternative are discussed below.

Oxygen Releasing Compound

ORC is a substance that when introduced to an aquifer, slowly releases oxygen and enhances the degradation of a contaminant. ORC is a proprietary formulation of magnesium peroxide, designed to provide a timed release of oxygen. ORC is manufactured as a powder, which can be mixed with water for slurry injection into the saturated zone. Through this process, *cis*-1,2-DCE can be reduced to vinyl chloride (VC), which is in turn degraded. Also, arsenic, iron, and manganese can be reduced to insoluble forms.

During the first year, a pilot study will be conducted, consisting of injecting ORC in a representative portion of the contaminant plume and monitoring groundwater quality in and downgradient of this pilot treatment zone over a 4- to 8-month period. This testing program would be initiated to confirm general project feasibility and design parameters prior to proceeding with a full-scale implementation. Specifically, measurements of degradation rates, the zone of influence of the ORC, the migration pathways of the ORC, the ORC volume required, the estimated efficiency of ORC use at SWMU 24, and the approximate clean up time required would be determined. During this period, monitoring of field redox parameters (dissolved oxygen, ORP, pH, and ferrous iron), biochemical oxygen demand (5-day), chemical oxygen demand, VOCs (including cis-1,2-DCE) and metals (including arsenic, iron, and manganese) will be conducted every month from select wells within the treatment area, upgradient, and downgradient of the treatment area. In addition, total organic carbon testing may need to be conducted on clean aquifer soil, as well as possibly metals treatability testing. Based upon the result of the pilot study, a final design of an ORC injection system would be developed. The following is a discussion of a preliminary design of a system, which may need to be redeveloped based on the results of the pilot study.

A 'grid' approach would be utilized for the full-scale ORC injection via a network of direct-push injection points. It is assumed that ORC would be applied using direct push hydraulic equipment. Drive rods would be pushed to the bottom of the contaminated saturated zone in areas with contaminant concentrations greater than the ARARs and risk-based PRGs and then an ORC/water slurry would be injected as the rods are withdrawn. The ORC would be used for at least 6 months. For the full scale, after application, samples would be collected every other month for a 6- to 8-month period to validate the enhancement of biodegradation processes from all wells within the treatment area, upgradient, and downgradient of the treatment area. It is assumed that four additional wells would need to be installed either upgradient and/or downgradient of the treatment area. Samples would be analyzed for the same parameters as during the pilot test. It is assumed that two re-applications of ORC would be required (during a second and third year), although each re-application would likely be done over a reduced area and dose amount compared to the initial application. After the initial biodegradation and geochemical trends have been identified (first application), the monitoring frequency would be decreased to an annual program.

A complication with the use of ORC is that they may tend to dissolve and migrate through higher permeability regions, such as the sandy aquifer regions, and not as readily reach areas where the contamination is bound in lower permeability regions, such as the silt and clay. Therefore, while ORC may greatly accelerate degradation in high permeability regions, lower permeability zones may not be as rapidly affected.

Institutional Controls and Long-Term Monitoring

The administrative measures to prevent groundwater use will be the same as included in Alternative 2. The long-term monitoring would also be implemented as in Alternative 2. The new wells would be installed coincident with the ORC injection so that sampling of the wells would provide information to most efficiently apply the ORC. The long-term monitoring program would begin after the ORC pilot test and full-scale applications (5^{th} year).

Table 3-1
Identification and Screening of Remedial Technologies for SWMU 1 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
No Action	None	Not applicable	No action.	X		Retain as baseline alternative
Institutional Controls	Administrative restrictions	Groundwater use restrictions	Property in the area would include groundwater use restrictions.	X		Potentially applicable if implemented in conjunction with other process options.
Monitoring	Monitoring Groundwater	Long-term Groundwater monitoring	Monitoring of contamination to track groundwater quality, and to monitor the potential for offsite migration.	X		Technically feasible
Free Product Collection	Extraction	Manual	Use of a bailer to remove floating hydrocarbon layer from the water table on a monthly basis until no more product is recoverable.	X		Based upon performance testing of pump systems and distribution of free product, this scenario is technically feasible.
		Pulsed positive-displacement product pump	Solar-powered unit would pump a few minutes a day until the product thickness decreases to less than 0.01 feet for 3 months.	X		This approach is technically feasible and has been used at Oceana since 1997.
		Constant-Rate Single-Pump System	Specialized pump that removes floating hydrocarbon layer from water table.		X	Groundwater does not contain significant recoverable free product to make this a cost-effective method.
		Constant-Rate Dual-Pump System	Pump system that lowers water table with one pump and removes hydrocarbon layer with other.		X	Groundwater does not contain significant recoverable free product to make this a cost-effective method.
Treatment	Biological treatment through Oxygen Releasing Compound (ORC)	Aerobic	Organics degraded by microorganisms in an aerobic environment.	X		May promote biodegradation of contamination in the sandy aquifer. A pilot study will be required to determine site-specific feasibility.

Table 3-1
Identification and Screening of Remedial Technologies for SWMU 1 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
Treatment (cont'd)		Anaerobic	Organics degraded by micro-organisms in an anaerobic environment.		X	Aerobic degradation typically used for biological treatment of petroleum hydrocarbons.
	Physical/chemical treatment	Precipitation	Change chemical equilibria to reduce solubility of contaminants.		X	Not feasible for removal of organic constituents.
		Air stripping	Large volumes of air mixed with water in a packed column to promote transfer of VOCs to air.		X	Groundwater does not contain high concentrations of VOCs.
		Carbon adsorption	Contaminants adsorbed onto activated carbon by passing water through carbon column.	X		Potentially applicable for any groundwater that may be extracted by free product collection system.
		Oil/water separation	Oil phase separated from water.	X		Applicable to separate oil from water if any groundwater is extracted.
		Reverse osmosis	High pressure used to force water through a membrane, leaving contaminants behind.		X	Not cost-effective for highly contaminated liquids. Usually used to treat inorganics.
		Ion exchange	Contaminated water passed through a resin bed where ions exchange between resin and water.		X	Not cost-effective for highly contaminated liquids. Usually used to treat inorganics.
		Chemical oxidation	Contaminated water mixed with an oxidant to destroy the organic compounds.		X	Elevated oil and grease concentration decrease treatment efficiency. Contaminant of concern is oil as TPH.
	In Situ Treatment	Bioventing	Air injected into vadose zone (free-product/TPH saturated soil) to promote volatilization and biodegradation of contaminants.		X	Relatively impermeable vadose zone and low contaminant concentrations would likely make this technology cost-prohibitive.

Table 3-1
Identification and Screening of Remedial Technologies for SWMU 1 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
Treatment (cont'd)	Discharge of treated groundwater	Surface water	Groundwater discharged into stormwater sewer system or ditch.	X		Potentially applicable; would have to modify and comply with Oceana's VPDES permit.
		POTW	Groundwater discharged into Hampton Roads Sanitary District system.		X	Local POTW does not accept treated groundwater from a RCRA/CERCLA remediation.
		Injection well	Treated groundwater discharged to groundwater injection well or field.		X	Implementation would be difficult and not cost effective relative to other options.
Free-Product Disposal	Disposal of collected free product	Off-site disposal facility	Free-product collected by recovery scenarios is removed and disposed of by off-site contractor at a permitted facility	X		Technically feasible.

Table 3-2
Identification and Screening of Remedial Technologies for SWMU 15 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
No Action	None	Not applicable	No action	X		Retain as baseline alternative
Institutional Controls	Administrative restrictions	Groundwater use restrictions	Property in the area would include groundwater use restrictions	X		Potentially applicable if implemented in conjunction with other process options.
Monitoring	Monitoring Groundwater	Long-term monitoring, monitoring active remediation or natural attenuation	Long-term monitoring of groundwater contamination to track groundwater quality, and to monitor the potential for offsite migration. Remediation or attenuation of contaminants could also monitored by collecting groundwater samples. Natural Attenuation relies on natural processes such as dilution, volatilization, adsorption, biodegradation, and plume migration to reduce contaminant concentrations over time.	X		Technically feasible for site contaminants.
Containment/ Collection	Physical barriers	Slurry walls	Subsurface barriers consisting of a vertically constructed trench excavated under a slurry		X	Horizontal isolation of contaminant could induce vertical migration into Yorktown Aquifer
		Sheet piling	Subsurface barriers consisting of sheet piling inserted around contaminant plume		X	Horizontal isolation of contaminant could induce vertical migration into Yorktown Aquifer
	Hydraulic barriers	Extraction wells	Series of pumping wells to extract contaminated groundwater and hydraulically isolate contaminant plume		X	Technically feasible, however would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		Subsurface drains/trenches	Perforated pipe in trenches backfilled with porous media to collect water		X	Based on location of contamination and depth of aquifer, trenches not as cost-effective as extraction wells
Treatment	Ex-Situ Biological treatment	Aerobic	Aerobic microorganisms are used to metabolize biodegradable organics in an aeration tank (e.g. fixed-film bioreactor system or combination bioreactor/activated carbon)		X	Technically feasible, however groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
	Physical/Chemical Treatment	Air stripping	Large volumes of air are mixed with the contaminated water in a packed column to promote transfer of VOCs to air		X	Technically feasible, however groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.

Table 3-2
Identification and Screening of Remedial Technologies for SWMU 15 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
Treatment (cont.)	Physical/Chemical Treatment (cont.)	Carbon adsorption	Contaminants adsorbed onto activated carbon by passing water through carbon column		X	Technically feasible, however groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		Reverse osmosis	High pressure used to force water through a membrane, leaving contaminants behind		X	Not cost-effective for removal of organic constituents relative to other technologies
		Chemical oxidation	Contaminated water mixed with an oxidant to break down the organic compounds into H_2O, CO_2, and Cl^-		X	Typically more difficult to operate than air stripping; however, would not be affected by iron in waste stream. Groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		Gravity oil-water separation	Mixture of oil and water flows into a tank where fuel or oil floats to the top		X	Not effective in separating most emulsions. Simple and effective for separating free product from water, however groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		Coalescing oil-water separation	Fine droplets of dissolved oil are collected on a filter medium. Enlarged droplets are then released and can be separated readily		X	Effective at treating most emulsions; less expensive than DAF. Emulsions are not anticipated in the waste stream.
		Dissolved air flotation (DAF)	Air is bubbled through the mixture; micron-size air bubbles attach to suspended POL particles and rise to the top of the separator		X	Effective at treating emulsions; expense not warranted where emulsions are not present or where coalescing separators are effective
Treatment	In-situ treatment	Reaction walls	Porous vertical wall containing a metal catalyst degrades halogenated compounds in groundwater as it passes through		X	Not effective for treating non-halogenated organics. Difficult to implement where bottom of aquifer is greater than 15-20 feet deep. Technology is still experimental with little data available.
		Aerobic degradation through Oxygen Releasing Compound (ORC)	An ORC is injected into the contaminated groundwater to enhance natural biodegradation	X		May promote biodegradation of contamination in the sandy aquifer. A pilot study will be required to determine site-specific feasibility.

Table 3-2
Identification and Screening of Remedial Technologies for SWMU 15 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
Discharge	Discharge of treated water	Surface water	Groundwater discharged into stormwater sewer system or ditch		X	Would have to comply with Oceana's VPDES permit. Not applicable because groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		POTW	Groundwater discharged into Hampton Roads Sanitary District system		X	Local POTW does not accept treated groundwater from a RCRA or CERCLA remediation project
		Injection well	Treated groundwater discharged to groundwater injection well or field		X	Implementation would be difficult relative to other options

Table 3-3
Identification and Screening of Remedial Technologies for SWMU 15 Soil

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
No Action	None	Not applicable	No action	X		Retain as baseline alternative
Institutional Controls	Administrative restrictions	Land use restrictions	Restrictions would be applied on future land use.		X	Given the small area of contamination and the relatively short amount of time projected to meet the cleanup goals, land use restrictions will not be required. In addition, there is currently a sign indicating that the SWMU is a restricted, installation restoration site.
Removal	Excavation	Standard excavating equipment (e.g. excavator)	Removal of soil for treatment and/or disposal.		X	Technically feasible, however cost prohibitive.
Disposal	Offsite waste management	Nonhazardous waste landfill (offsite)	Transport and dispose of untreated or treated material in a nonhazardous (Subtitle D) landfill.		X	Not applicable
		Hazardous waste management facility (offsite)	Transport and dispose of lead-contaminated soil in an approved hazardous (Subtitle C) waste facility (soil may need to be treated prior to disposal).		X	Not applicable
In situ Treatment	Biological treatment	Landfarming	Organically contaminated soil are applied onto the soil surface and periodically turned over or tilled into the soil to aerate the waste.	X		Applicable. Landfarming has been used successfully at a similarly contaminated site at the facility.
Ex *situ* Treatment	Biological treatment	Composting	The storage of highly biodegradable and structurally firm material (e.g. wood chips) with a small percentage of biodegradable waste, to decompose organic compounds. Must collect leachate and runoff water from the composting beds.		X	Technically feasible, however cost prohibitive in comparison to an in-situ technology.
		White rot fungus	Moisturized air on wood chips is used in a reactor for biodegradation by white rot fungus (uses lignin-degrading or wood-rotting enzymes).		X	Technically feasible, however cost prohibitive in comparison to an in-situ technology.
		Bioslurry reactor	An aqueous slurry is created by combining soil or sludge with water and other additives. Aerobic bacteria degrade contaminated materials. Batch and continuous flow bioreactors are used to process contaminated soil.		X	Technically feasible, however cost prohibitive in comparison to an in-situ technology.
		Aerobic digestion	Organic wastes are oxidized through the use of a mixed culture of microorganisms under aerobic conditions in a bioreactor.		X	Technically feasible, however cost prohibitive in comparison to an in-situ technology.

Table 3-4
Identification and Screening of Remedial Technologies for SWMU 24 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
No Action	None	Not applicable	No action	X		Retain as baseline alternative
Institutional Controls	Administrative restrictions	Groundwater use restrictions	Property in the area would include groundwater use restrictions	X		Potentially applicable if implemented in conjunction with other process options.
Monitoring	Monitoring Groundwater	Long-term Groundwater monitoring	Long-term monitoring of groundwater contamination to track groundwater quality, and to monitor the potential for offsite migration.	X		Technically feasible for site contaminants to track groundwater quality.
Containment/ Collection	Physical barriers	Slurry walls	Subsurface barriers consisting of a vertically constructed trench excavated under a slurry		X	Horizontal isolation of contaminant could induce vertical migration into Yorktown Aquifer
		Sheet piling	Subsurface barriers consisting of sheet piling inserted around contaminant plume		X	Horizontal isolation of contaminant could induce vertical migration into Yorktown Aquifer
	Hydraulic barriers	Extraction wells	Series of pumping wells to extract contaminated groundwater and hydraulically isolate contaminant plume		X	Technically feasible, however would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		Subsurface drains/trenches	Perforated pipe in trenches backfilled with porous media to collect water		X	Based on location of contamination and depth of aquifer, trenches not as cost-effective as extraction wells
Treatment	Ex-situ Biological treatment	Aerobic	Aerobic microorganisms are used to metabolize biodegradable organics in an aeration tank		X	Emerging technologies can remove chlorinated organics, but these high-maintenance systems are not cost-effective compared to conventional technologies for volatile compounds.
	Physical/Chemical Treatment	Air stripping	Large volumes of air are mixed with the contaminated water in a packed column to promote transfer of VOCs to air. Treatment of off-gas may be necessary.		X	Technically feasible, however groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		Carbon adsorption	Contaminants adsorbed onto activated carbon by passing water through carbon column. Typically more expensive than air stripping for large volumes of water and long-term use.		X	Technically feasible, however groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.

Table 3-4
Identification and Screening of Remedial Technologies for SWMU 24 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
Treatment (cont.)	Physical/Chemical Treatment (cont.)	Reverse osmosis	High pressure used to force water through a membrane, leaving contaminants behind		X	Not cost-effective for removal of organic constituents relative to other technologies
		Chemical oxidation	Contaminated water mixed with an oxidant to break down the organic compounds into H_2O, CO_2, and Cl^-		X	Potentially applicable. Typically more difficult to operate than air stripping; however, would not be affected by iron in waste stream. Groundwater extraction would be cost prohibitive, especially for the relatively low levels (and relatively small area) of contamination at the site.
		Gravity oil-water separation	Mixture of oil and water flows into a tank where fuel or oil floats to the top		X	No free product detected at this site; oil-water mixtures or emulsions not anticipated.
		Coalescing oil-water separation	Fine droplets of dissolved oil are collected on a filter medium. Enlarged droplets are then released and can be separated readily		X	No free product detected at this site; oil-water mixtures or emulsions not anticipated.
		Dissolved air flotation (DAF)	Air is bubbled through the mixture; micron-size air bubbles attach to suspended POL particles and rise to the top of the separator		X	No free product detected at this site; oil-water mixtures or emulsions not anticipated.
	In-situ treatment	Aerobic biodegradation with biosparging	Air and necessary nutrients are injected into the contaminated area to enhance natural biodegradation		X	Chlorinated VOCs are recalcitrant to aerobic biodegradation.
		Volatilization with biosparging	Air injected into groundwater through a system of wells to remove volatiles and promote biodegradation. Treatment of off-gas may be necessary.		X	Site geology would make it prohibitively costly to collect contaminated soil gas.
		Reaction walls	Porous vertical wall containing a metal catalyst degrades halogenated compounds in groundwater as it passes through		X	Difficult to implement where bottom of aquifer is greater than 15-20 feet deep. Technology is still experimental with little data available.
		Biodegradation through use of ORC	Oxygen is released into the contaminated groundwater to encourage reductive dehalogenation.	X		Technically feasible for treating inorganics and 1,2 DCE, and subsequently VC. A pilot study will be required to determine site-specific feasibility.
		In-well air stripping (UVB or No-VOCs)	Air is injected up through water column in the well casing to circulate groundwater and strip out VOCs. Offgas is pulled from well and treated as necessary.		X	Pilot test was effective, however, installation of No-VOCs could be cost-prohibitive for contaminant concentrations, and would not treat the inorganics.

Table 3-4
Identification and Screening of Remedial Technologies for SWMU 24 Groundwater

General Response Action	Remediation or Technology	Process Options	Description	Screening Action		Screening Comments
				Retain	Reject	
Discharge	Discharge of treated water	Surface water	Groundwater discharged into stormwater sewer system or ditch	X		Potentially applicable; would have to comply with Oceana's VPDES permit
		POTW	Groundwater discharged into Hampton Roads Sanitary District system		X	Local POTW does not accept treated groundwater from a RCRA or CERCLA remediation project
		Injection well	Treated groundwater discharged to groundwater injection well or field		X	Implementation would be difficult relative to other options
Off-gas treatment	Physical/chemical treatment	Carbon adsorption	Contaminants adsorbed onto activated carbon by passing air through carbon column		X	Not applicable.
		Synthetic polymer membranes	Membrane allows organic contaminant to pass through, leaving clean residual air stream		X	Not applicable.
		Resin filter beds	Contaminants adsorbed onto resin by passing air through filter bed. May be less expensive over time than replacement of activated carbon.		X	Not applicable.
		Condensation	Stripping stream cooled to low temperature to condense contaminant molecules for recovery or disposal		X	Low concentration of VOCs in air stream do not require this level of technology
	Thermal Treatment	Direct fume incineration	Stripping stream raised to high temperature to oxidize contaminant molecules		X	Low concentration of VOCs in air stream do not require this level of technology
	Biological Treatment	Fixed film bioreactor	Chlorinated VOCs in gas phase are cometabolized by methanotrophic organisms		X	Would require a high degree of maintenance compared to other technologies

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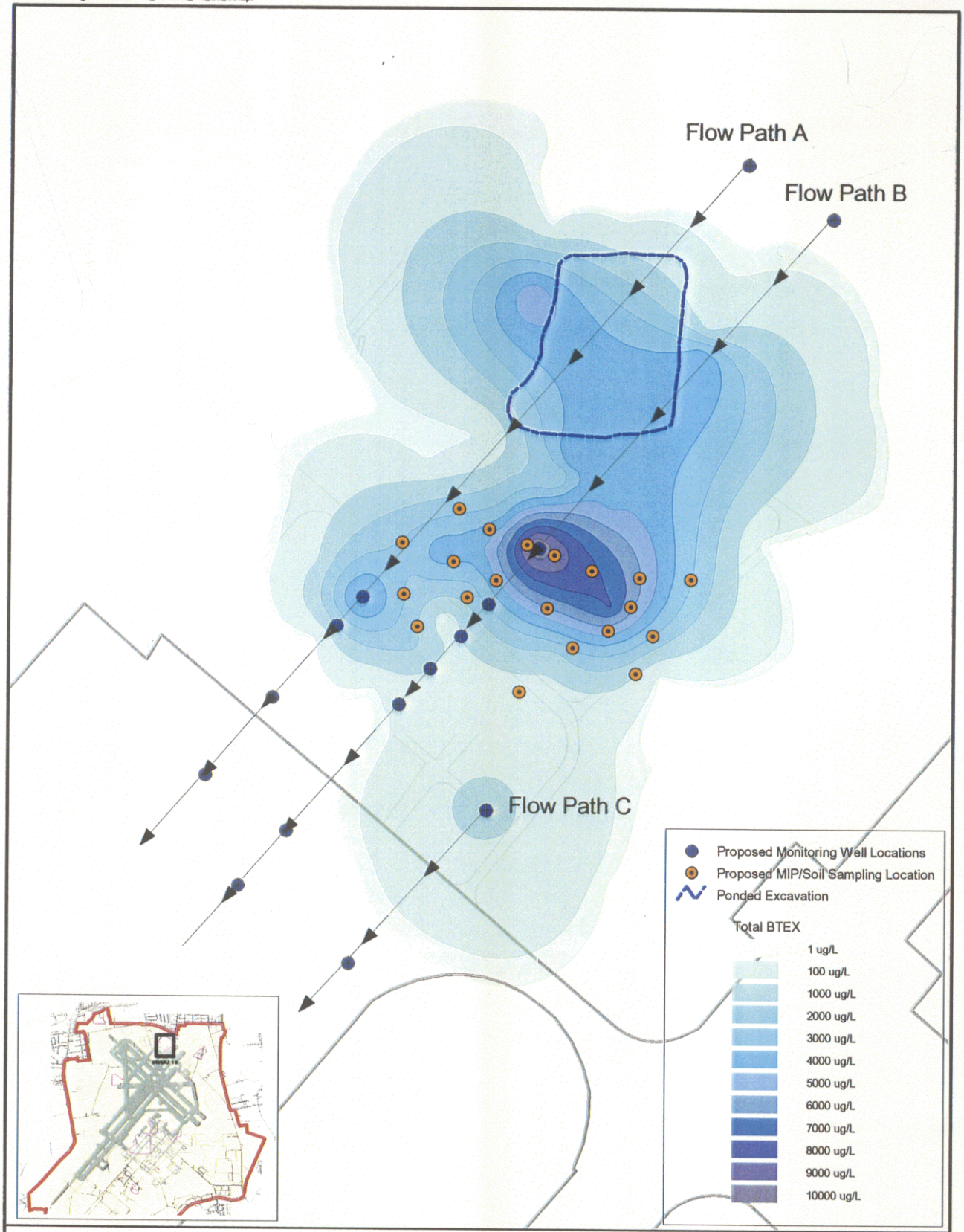

Figure 3-1
Proposed Soil Characterization and Monitoring Well Locations for Monitored Natural Attenuation - SWMU 15
NAS Oceana, Virginia Beach, Virginia

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00557EB24

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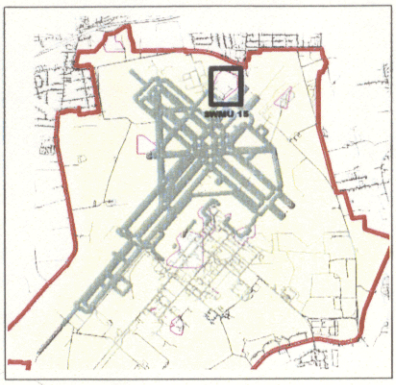

15-SS08
15-SB42
15-SB43
15-SB41
15-SB44
15-SB40
15-SS09
15-SS07
15-SB35
15-SB39
15-SB38
15-SB36
15-SB37
15-SS06

Ponded Excavation
Surface Soil Sample Locations
Excavation Perimeter Subsurface Soil Samples (1-2 feet)
Proposed Area of Landfarming (46,065 square feet)

N
W
E
S

0 80 160 240 Feet

Figure 3-2
Proposed Area of Landfarming - SWMU 15
NAS Oceana, Virginia Beach, Virginia

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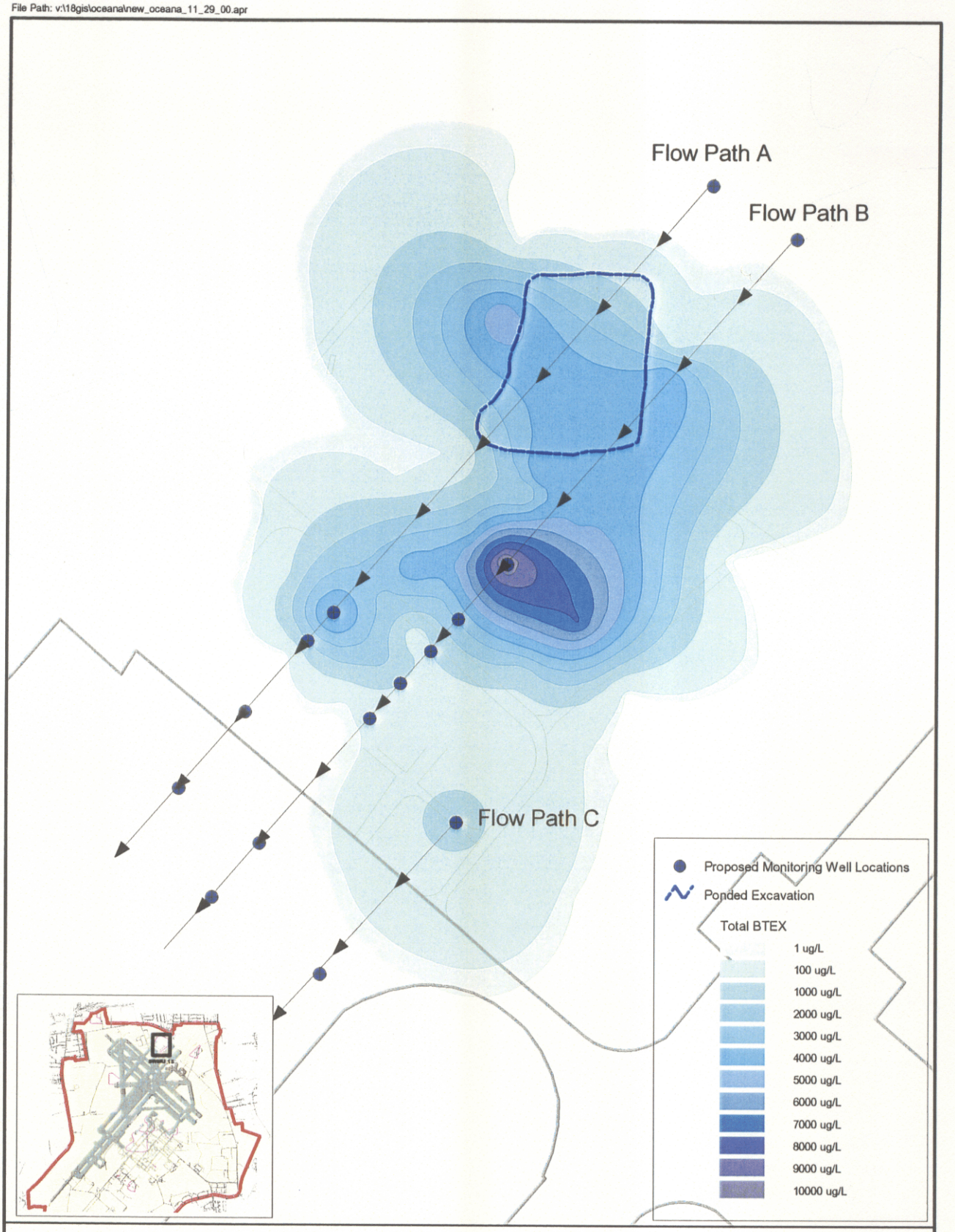

Figure 3-3
Proposed Monitoring Well Locations
for Long-Term Monitoring - SWMU 15
NAS Oceana, Virginia Beach, Virginia

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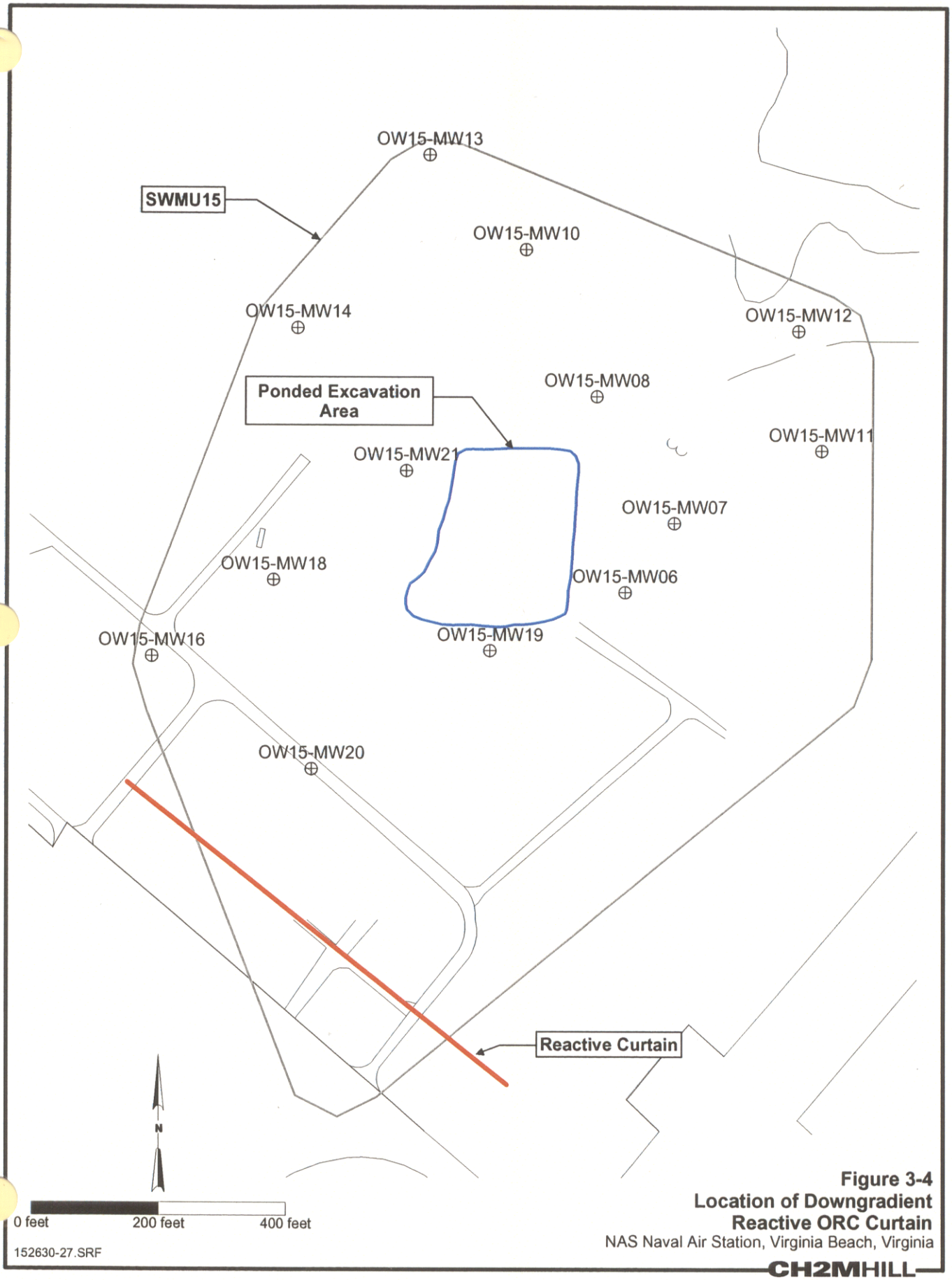

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Figure 3-4
Location of Downgradient Reactive ORC Curtain
NAS Naval Air Station, Virginia Beach, Virginia

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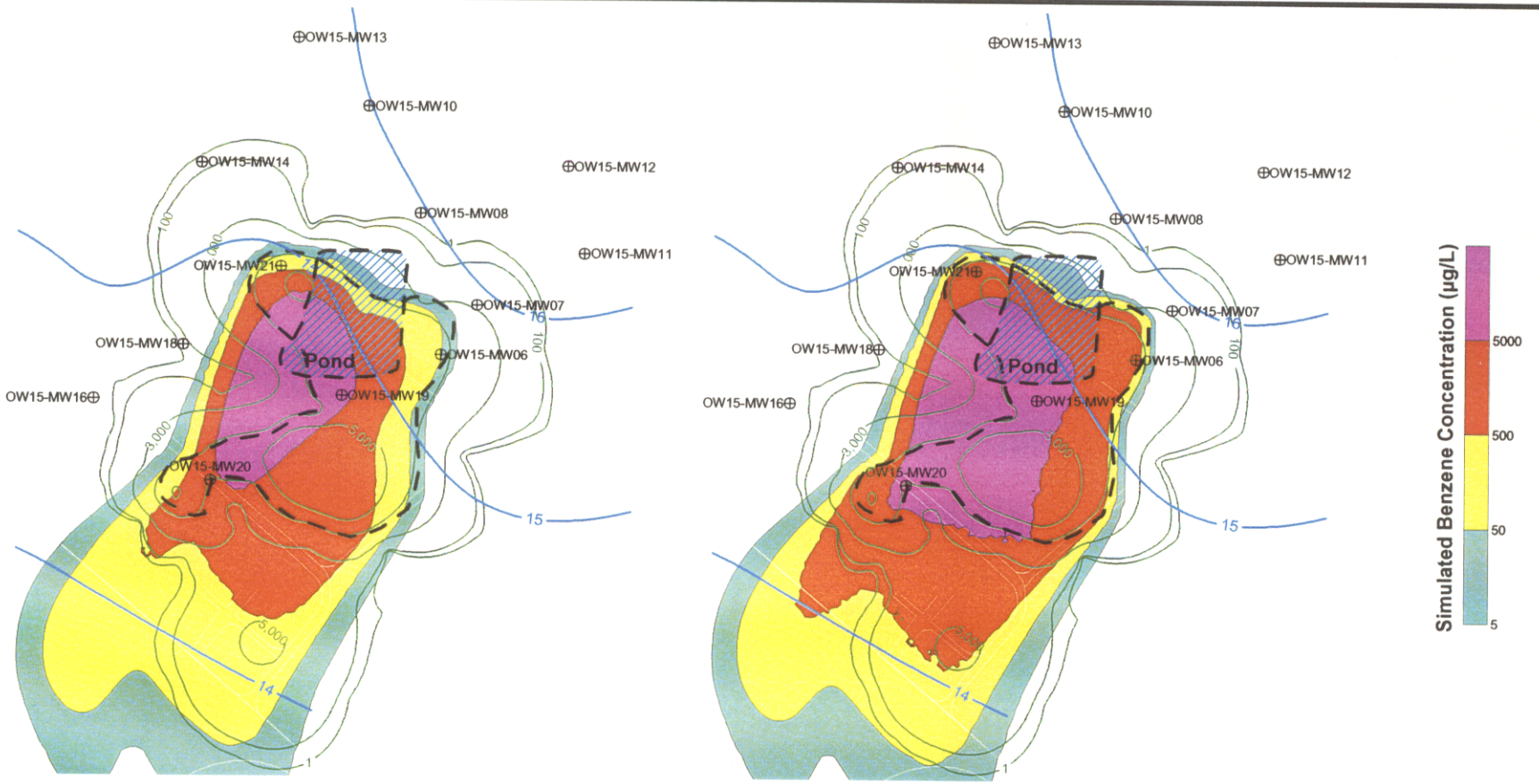

Figure 3-5
Simulated Benzene Concentrations in the Year 2000 (Shallow and Deep Source)
NAS Naval Air Station, Virginia Beach, Virginia

CH2MHILL

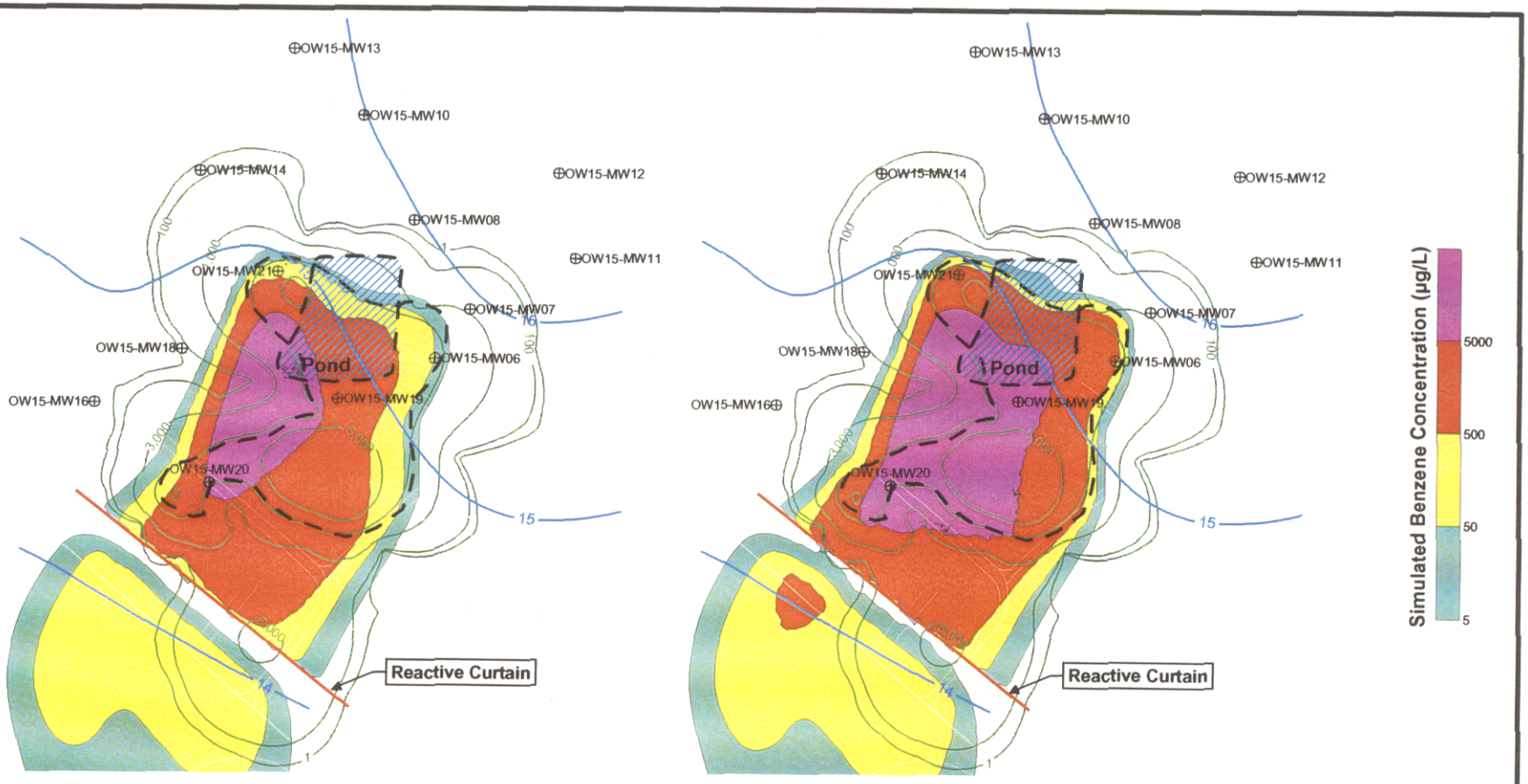

Figure 3-6
Simulated Benzene Concentrations in 5 Years
Downgradient Reactive Curtain Alternative
(Small Shallow and Large Deep Source)
NAS Naval Air Station, Virginia Beach, Virginia

CH2MHILL

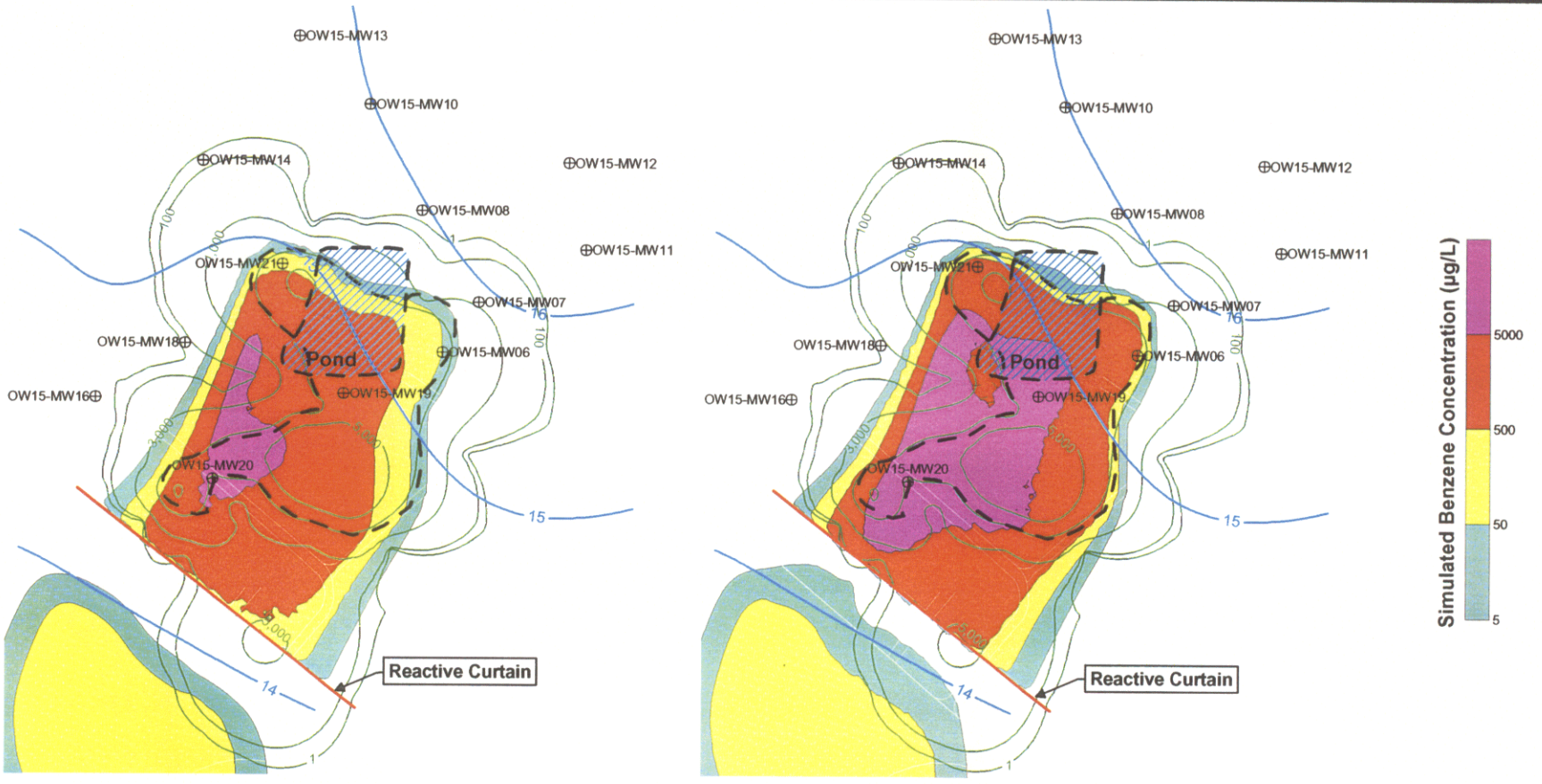

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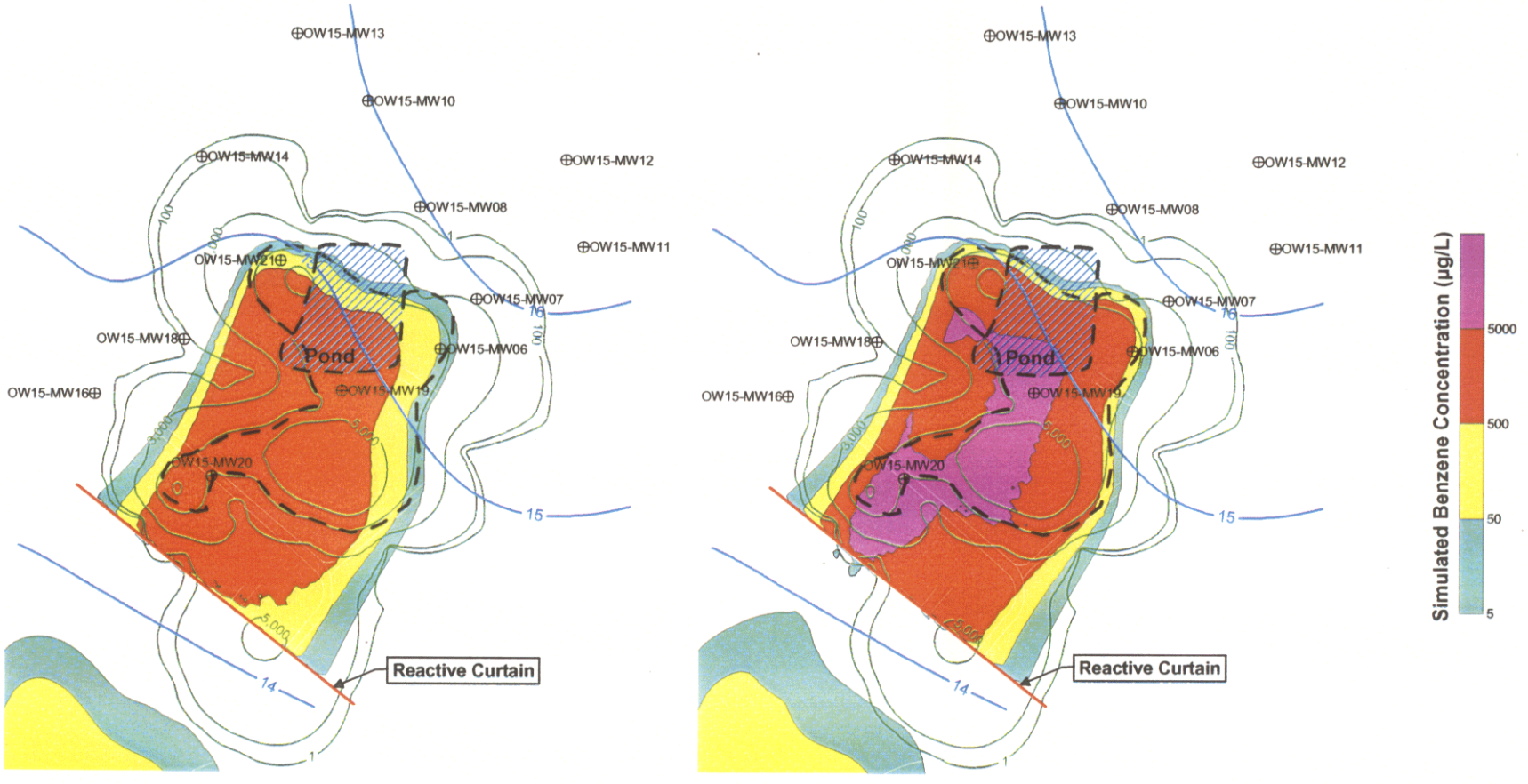
Figure 3-7
Simulated Benzene Concentrations in 15 Years
Downgradient Reactive Curtain Alternative
(Small Shallow and Large Deep Source)
NAS Naval Air Station, Virginia Beach, Virginia

CH2MHILL



Shallow Columbia Aquifer (4 to 12 feet BGS)

Deep Columbia Aquifer (12 to 20 feet BGS)

Legend:

- Source Zone
- Total BTEX (µg/L)
- Groundwater Elevation (feet MSL)
- Monitoring Well

N

0 feet 350 feet 700 feet

152630-31.SRF

Figure 3-8
Simulated Benzene Concentrations in 30 Years
Downgradient Reactive Curtain Alternative
(Small Shallow and Large Deep Source)
NAS Naval Air Station, Virginia Beach, Virginia

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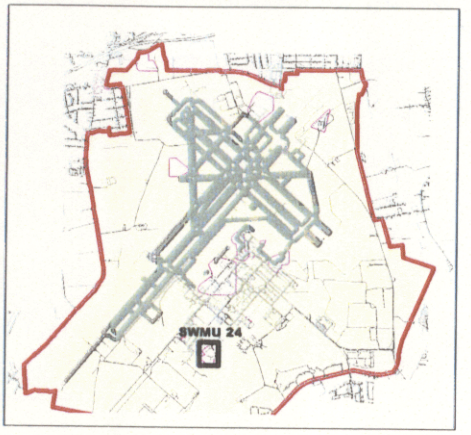

24-MW11

24-MW10

840

842

24-MW5

24-MW6

844

843

24-MW1D

24-MW4

24-MW1

24-MW3

24-MW2

24-MW9

24-MW8

24-MW7

Proposed Monitoring Wells
Monitoring Well Locations
DCE Hot Spot Area
10 ug/L
20 ug/L
30 ug/L
40 ug/L
50 ug/L
60 ug/L

N
W
E
S

0 80 160 240 Feet

Figure 3-9
Long-Term Monitoring Well Network - SWMU 24
NAS Oceana, Virginia Beach, Virginia

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4.0 Detailed Analysis of Remedial Alternative

The remedial alternatives that were developed in Section 3.0 are evaluated in detail in this section. Each alternative was developed to address threats to human health posed by contamination at SWMUs 1, 15, and 24. The National Contingency Plan (NCP) requires that the remedial alternatives be evaluated against the nine criteria listed below, as defined in the NCP. The first seven criteria are addressed in this Feasibility Study (FS). The last two criteria will be addressed in the record of decision (ROD). The nine criteria are:

- Protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

4.1 Evaluation Criteria

The detailed alternative analysis is the means for assembling and evaluating technical and policy considerations to develop the rationale for selecting a remedy. The following paragraphs define and detail each of the nine criteria.

4.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion is an assessment of whether each alternative achieves and maintains adequate protection of human health and the environment. The overall appraisal of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. Another consideration is the statutory preference for onsite remedial actions.

4.1.2 Compliance with ARARs and To-Be-Considered Criteria

This evaluation criterion is used to determine whether an alternative would meet all federal, state, and local ARARs and to-be-considered criteria. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA would be discussed.

4.1.3 Long-Term Effectiveness and Permanence

Under this criterion the results of a remedial alternative are evaluated in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the actions or controls that may be required to manage the risk posed by treatment residuals or untreated wastes. Factors to be considered and addressed are magnitude of residual risk, adequacy of controls, and reliability of

controls. Magnitude of residual risk is the assessment of the risk remaining from untreated waste or treatment residuals after remediation. Adequacy and reliability of controls is the evaluation of the controls that can be used to manage treatment residuals or untreated wastes that remain at the facility. The evaluation may include an assessment of institutional controls to determine whether they are sufficient in protecting human and environmental receptors.

4.1.4 Reduction of Toxicity, Mobility, and Volume

This evaluation criterion addresses the statutory preference for selecting remedial actions that, as their principal element, use technologies that permanently remediate and significantly reduce the toxicity, mobility, or volume of the hazardous substances. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction of contaminant mobility, or reduction of total volume of contaminated media. When evaluating this criterion, an assessment is made as to whether remediation is used to reduce principal threats, including the extent to which toxicity, mobility, or volume is reduced either separately or in combination with one another. Factors that would be focused on include:

- Remediation processes employed by the remedy
- Amount of hazardous materials that would be remediated
- Degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction
- Degree to which the remediation would be irreversible
- Type and quantity of treatment residuals that would remain following remediation
- Whether the alternative would satisfy the statutory preference for treatment as a principal element

4.1.5 Short-Term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial action objectives (RAOs) are met. Alternatives would be evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The following factors remedial action objectives would be addressed for each alternative:

- Protection of the community during remedial actions
- Protection of workers during remedial actions
- Environmental impacts during remedial actions
- Time until RAOs are achieved

4.1.6 Implementability

The implementability criterion addresses the technical and administrative feasibility of executing an alternative and the availability of various services and materials required

during its implementation. Technical feasibility includes construction, operation, reliability of technology, ease of undertaking additional remedial action, and monitoring. Administrative feasibility refers to the activities needed to coordinate with other offices and agencies (e.g., local permits). Availability of services and materials includes availability of adequate off-facility treatment, storage capacity, and disposal services; necessary equipment and specialists; services and materials; and prospective technologies.

4.1.7 Cost

For the cost analysis of alternatives, the expenditures required to complete each remedial action are estimated in terms of both capital and annual O&M costs. Using these values, a present-worth calculation for each alternative then can be made for comparison.

Capital costs consist of direct and indirect costs. Direct costs include the cost of construction, equipment, land and site development, treatment, transportation, and disposal. Indirect costs include engineering expenses, license or permit costs, and contingency allowances.

Annual O&M costs are the post-construction costs required to ensure the continued effectiveness of the remedial action. Components of annual O&M cost include the cost of operating labor, maintenance materials and labor, auxiliary materials and energy, residue disposal, purchased services, administration, maintenance reserve and contingency funds, rehabilitation, monitoring, and periodic site reviews.

Expenditures that occur over a time period are analyzed using present worth, which discounts all future costs to a common base year. Present-worth analysis allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the life of the remedial project. Assumptions associated with the present-worth calculations include a discount rate of 4.2 percent (OMB Circular No. A-94, Appendix C, Revised January 2000), cost estimates in the planning years in constant dollars, and a period of performance that would vary depending on the activity, but would not exceed 30 years.

The cost estimates for this section are provided to an accuracy of +50 percent to -30 percent. The alternative cost estimates are in 2000 dollars and are based on conceptual design from information available at the time of this study. The actual cost of the project would depend on the final scope and design of the selected remedial action, the schedule of implementation, competitive market conditions, and other variables. Most of these factors are not expected to affect the relative cost differences between alternatives.

4.1.8 State Acceptance

This assessment evaluates the technical and administrative issues and concerns the state may have regarding each of the alternatives. This criterion is not discussed in this report, but would be addressed in the Proposed Remedial Action Plan (PRAP) and the ROD.

4.1.9 Community Acceptance

This assessment evaluates the issues and concerns the public may have regarding each of the alternatives. As with state acceptance, this criterion is not discussed in this report, but would be addressed in the PRAP and the ROD.

4.2 Evaluation of Remedial Alternatives for SWMUs 1, 15, and 24

4.2.1 Detailed Analysis of Remedial Alternatives

In Section 3.3, 3.4, and 3.5, three or four remedial alternatives, including the No Action alternative, were developed for each SWMU with the goal of meeting the site-specific RAOs. This section provides a detailed evaluation of each alternative discussed for SWMUs 1, 15, and 24 on the basis of the seven NCP criteria previously discussed. The detailed evaluation for each alternative for SWMUs 1, 15, and 24 is presented in Table 4-1, 4-2, and 4-3, respectively.

Table 4-1
Analysis of Remedial Alternatives for Groundwater at SWMU 1

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Free-Product Removal, Institutional Controls with LTM	Alternative 3 ORC, Free-Product Removal, Institutional Controls with LTM
Overall Protection of Human Health and Environment			
Prevention of unacceptable risks to potential receptors to the groundwater	There is potential risk to receptors from residential use of groundwater. Although residential use of the groundwater is unlikely, there would be no measures would be in place to prevent it.	There is potential risk to receptors from residential use of groundwater. However, institutional controls would restrict residential use of the groundwater. LTM will detect any change in current groundwater concentrations and the potential for offsite migration. Free-product removal will reduce contaminant dissolution and migration.	See Alternative 2. In addition, because the residential use of groundwater is unlikely, the benefit of potentially reducing contamination levels through ORC injection is not warranted.
Compliance with ARARs			
Action-Specific ARARs	Not relevant.	Meets all action-specific ARARs.	Meets all action-specific ARARs.
Location-Specific ARARs	Not relevant.	Meets all location-specific ARARs.	Meets all location-specific ARARs.
Chemical-Specific ARARs	Since there is no ARAR (MCL) for napthalene, a risk-based PRG was calculated. Since no action is taken, the PRG would not be met.	Institutional controls would restrict future residential use of the groundwater, therefore, the PRG would be met. LTM would track groundwater quality and the potential for offsite migration.	See Alternative 2. In addition, ORC application may reduce contaminant concentrations, however, with institutional controls in place, this may not be necessary. LTM would track groundwater quality and the potential for offsite migration.
Long Term Effectiveness and Permanence			
Groundwater	Source not remediated. Potential future risk posed by residential use of groundwater. No permanent means to prevent future exposure to groundwater in a manner that would result in unacceptable risks.	Source not remediated. Potential future risk posed by residential use of groundwater. Institutional controls and monitoring would be relied upon to eliminate unacceptable risks to groundwater.	See Alternative 2. In addition, source may be remediated through the use of ORC.

Table 4-1
Analysis of Remedial Alternatives for Groundwater at SWMU 1

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Free-Product Removal, Institutional Controls with LTM	Alternative 3 ORC, Free-Product Removal, Institutional Controls with LTM
Need for Five Year Review	Because contaminated groundwater remains onsite, five-year reviews would be required.	See Alternative 1.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume			
Groundwater	Toxicity and volume reduction may be reduced due by natural degradation.	See Alternative 1.	See Alternative 1.
Type and Quantity of Residuals Remaining After Remediation	No treatment undertaken. Therefore, groundwater contamination remains onsite.	No treatment undertaken. Groundwater contamination remains onsite.	Treatment consists of ORC. Depending on effectiveness of ORC, residual contamination may remain after remediation.
Short-Term Effectiveness			
Groundwater	Remedy implementation does not add to risk.	Remedy implementation does not add to risk.	A moderate amount of construction traffic will be associated with hauling material from offsite sources.
Time Until Action is Complete	Not applicable.	Annual long-term monitoring will occur as deemed necessary.	ORC insertion is expected to take effect in approximately four years. Annual long-term monitoring will continue as deemed necessary.

Table 4-1
Analysis of Remedial Alternatives for Groundwater at SWMU 1

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Free-Product Removal, Institutional Controls with LTM	Alternative 3 ORC, Free-Product Removal, Institutional Controls with LTM
Implementability			
Ability to Construct and Operate	Not applicable.	Some construction required to install monitoring wells for LTM. Operation would consist of long-term monitoring. Groundwater use restrictions would require consent from base command.	The ORC injection would be performed using traditional direct-push methods. Operation would consist of ORC injection and long-term monitoring. Some construction required to install monitoring wells for LTM. Groundwater use restrictions would require consent from base command.
Ease of Implementing Additional Action if Needed	Very easy to implement additional action.	See Alternative 1.	See Alternative 1.
Ability to Monitor Effectiveness	Easily monitored during five-year site reviews.	Easily monitored during five-year site reviews. LTM will also be used to evaluate the groundwater quality.	ORC effectiveness will be determined through traditional sampling methods. LTM also will be used to evaluate groundwater quality. Easily monitored during five-year site reviews.
Cost			
Capital Cost	$0	$282,300	$318,300
Annual O&M Cost	$2,000	$80,500	$83,900
Present-Worth	$6,500	$1,617,700	$2,067,300

Table 4-2
Analysis of Remedial Alternatives for Groundwater and Surface Soil at SWMU 15

Evaluation Criteria	Alternative 1 No Action	Alternative 2 MNA, Institutional Controls, Landfarming	Alternative 3 Long-Term Monitoring, IC, Landfarming	Alternative 4 Downgradient Reactive Curtain of ORC, Long-term Monitoring, IC, Landfarming
Overall Protection of Human Health and Environment				
Exposure to surface soil posing unacceptable risks	Current unacceptable risk is posed to potential industrial receptors and ecological receptors by soil at the site. No reduction in potential risk of exposure to future human and ecological receptors, either.	Landfarming would likely reduce current and potential future risk to both human and ecological receptors.	See Alternative 2.	See Alternative 2.
Prevention of unacceptable risks to potential receptors to the groundwater	Risk to receptors from groundwater is posed by future and current conditions at the site if the groundwater is used for residential use or if excavation into the aquifer causes non-consumptive contact, respectively. Although residential use of the groundwater and excavations into the water table aquifer are unlikely, there would be no measures would be in place to prevent it.	Risk to receptors from groundwater is posed by future and current conditions at the site if the groundwater is used for residential use or if excavation into the aquifer causes non-consumptive contact, respectively. Although residential use of the groundwater and excavations into the water table aquifer are unlikely, institutional controls would prevent it. Contamination is tied up in silt and clay, is not prone to migration, and is readily degrading as it moves into the sandy aquifer. MNA will detect any change in current groundwater concentrations.	Risk to receptors from groundwater is posed by future and current conditions at the site if the groundwater is used for residential use or if excavation into the aquifer causes non-consumptive contact, respectively. Although residential use of the groundwater and excavations into the water table aquifer are unlikely, institutional controls would prevent it. LTM will detect any change in current groundwater concentrations.	See Alternative 2. ORC injection may prevent the potential for offsite contaminant migration (pilot study would be necessary), however, application of this technology may not be warranted if the concentrations of dissolved contaminants in groundwater concentrations meet current regulatory guidelines before adversely affecting potential downgradient receptors. Long-term monitoring would determine the effectiveness of the ORC as well as track changes in groundwater quality.

Table 4-2
Analysis of Remedial Alternatives for Groundwater and Surface Soil at SWMU 15

Evaluation Criteria	Alternative 1 No Action	Alternative 2 MNA, Institutional Controls, Landfarming	Alternative 3 Long-Term Monitoring, IC, Landfarming	Alternative 4 Downgradient Reactive Curtain of ORC, Long-term Monitoring, IC, Landfarming
Compliance with ARARs				
Chemical-Specific ARARs	No chemical-specific ARARs are available for soil. Instead, risk-based PRGs were calculated for soil remediation for protection of human health (individual PAHs). A cleanup level for total PAHs also has been established for protection of ecological receptors from the soil. ARARs (MCLs) and risk-based PRGs (where MCLs are not available) were established for groundwater. Since no action is taken under this alternative, ARARs and to-be considered criteria would not be met.	No chemical-specific ARARs are available for soil. Instead, risk-based PRGs were calculated for soil remediation for protection of human health (individual PAHs). A cleanup level for total PAHs also has been established for protection of ecological receptors from the soil. Landfarming would likely reduce soil contaminant concentrations to meet the PRGs. ARARs (MCLs) and risk-based PRGs (where MCLs are not available) were established for groundwater. Institutional controls at SWMU 15 would include restrictions on future residential use of the groundwater as well as on activities that would involve excavations into the shallow water table aquifer. Therefore, the ARARs and PRGs would be met. MNA would track groundwater quality.	See Alternative 2.	See Alternative 2 for soil. ARARs (MCLs) and risk-based PRGs (where MCLs are not available) were established for groundwater. Institutional controls at SWMU 15 would include restrictions on future residential use of the groundwater as well as on activities that would involve excavations into the shallow water table aquifer. Therefore, the ARARs and PRGs would be met. ORC application may prevent the potential offsite migration of contaminants, however, application of this technology may not be warranted if the concentrations of dissolved contaminants in groundwater concentrations meet current regulatory guidelines before adversely affecting potential downgradient receptors. LTM would determine the effectiveness of the ORC as well as track groundwater quality.
Location-Specific ARARs	Not relevant.	Meets all location-specific ARARs.	Meets all location-specific ARARs.	Meets all location-specific ARARs.

Table 4-2
Analysis of Remedial Alternatives for Groundwater and Surface Soil at SWMU 15

Evaluation Criteria	Alternative 1 No Action	Alternative 2 MNA, Institutional Controls, Landfarming	Alternative 3 Long-Term Monitoring, IC, Landfarming	Alternative 4 Downgradient Reactive Curtain of ORC, Long-term Monitoring, IC, Landfarming
Action-Specific ARARs	Not relevant.	Meets all action-specific ARARs.	Meets all action-specific ARARs.	Meets all action-specific ARARs.
Long Term Effectiveness and Permanence				
Groundwater and Surface Soil	Source not remediated. No permanent means to prevent current and future use of site in a manner that would result in unacceptable risks to groundwater and soil.	Soil remediated through landfarming. Potential risk posed by residential use of groundwater. Institutional controls and MNA would be relied upon to restrict residential groundwater use and excavations into the water table aquifer and reduce/monitor groundwater contaminant levels.	Soil remediated through landfarming. Potential risk posed by residential use of groundwater. Institutional controls and LTM would be relied upon to restrict residential groundwater use and excavations into the water table aquifer and monitor groundwater contaminant levels.	Source remediated through landfarming. Potential risk posed by residential use of groundwater. ORC application, institutional controls and LTM would be relied upon to restrict residential groundwater use and excavations into the water table aquifer and reduce/monitor groundwater contaminant levels.
Need for Five Year Review	Because contaminated media (soil and groundwater) remains onsite, five-year reviews would be required.	Because contaminated media (groundwater) would remain onsite, five-year reviews would be required.	See Alternative 2.	See Alternative 2.
Reduction of Toxicity, Mobility, or Volume				
Groundwater and Surface Soil	Toxicity, mobility, and volume associated with contaminated media would remain at current levels.	Toxicity, mobility, and volume associated with contaminated groundwater may be reduced by natural degradation of select contaminants of concern only. Toxicity, mobility, and volume reduction in soil would likely be attained through landfarming.	See Alternative 2.	Toxicity, mobility, and volume associated with migration contaminated media may be reduced from ORC (pilot study would be necessary). Toxicity, mobility, and volume reduction in soil would likely be attained through landfarming.

Table 4-2
Analysis of Remedial Alternatives for Groundwater and Surface Soil at SWMU 15

Evaluation Criteria	**Alternative 1** *No Action*	**Alternative 2** MNA, Institutional Controls, Landfarming	**Alternative 3** Long-Term Monitoring, IC, Landfarming	**Alternative 4** Downgradient Reactive Curtain of ORC, Long-term Monitoring, IC, Landfarming
Type and Quantity of Residuals Remaining After Remediation	No treatment undertaken. Therefore, groundwater and surface soil contamination remain onsite.	Soil treatment consists of landfarming, therefore contamination will likely be reduced to meet the PRGs. Some groundwater contamination may attenuate naturally.	See Alternative 2.	See Alternative 2. In addition, depending on migration of the plume and the effectiveness of the ORC barrier, some residual contamination may remain after remediation.
Short-Term Effectiveness				
Groundwater and Surface Soil	Remedy implementation does not add to risk.	Remedy implementation does not add to risk. Agricultural equipment will be used for landfarming.	See Alternative 2.	See Alternative 2. In addition, a moderate amount of construction traffic will be associated with hauling material from offsite sources.
Time Until Action is Complete	Not applicable.	MNA will occur as deemed necessary (assumed 30 years). Landfarming and collection of confirmatory samples will likely occur for a spring and fall season.	Annual long-term monitoring will occur as deemed necessary. Landfarming and collection of confirmatory samples will likely occur for a spring and fall season.	ORC insertion is expected to take effect within a few years, although this cannot be predicted until a pilot study is conducted. Annual long-term monitoring will continue as deemed necessary. Landfarming and collection of confirmatory samples will likely occur for a spring and fall season.

Table 4-2
Analysis of Remedial Alternatives for Groundwater and Surface Soil at SWMU 15

Evaluation Criteria	Alternative 1 No Action	Alternative 2 MNA, Institutional Controls, Landfarming	Alternative 3 Long-Term Monitoring, IC, Landfarming	Alternative 4 Downgradient Reactive Curtain of ORC, Long-term Monitoring, IC, Landfarming
Implementability				
Ability to Construct and Operate	Not applicable.	Agricultural equipment required for landfarming. Some construction required to install monitoring wells for MNA. Operation would consist of long-term monitoring for MNA parameters to monitor contaminant degradation. Groundwater use and excavation restrictions would require consent from base command.	Agricultural equipment required for landfarming. Some construction required to install monitoring wells for LTM. Operation would consist of long-term monitoring. Groundwater use and excavation restrictions would require consent from base command.	Agricultural equipment required for landfarming. The ORC barrier would be installed using traditional construction methods. Operation would consist of injecting the ORC, and long-term monitoring. Groundwater use and excavation restrictions would require consent from base command.
Ease of Implementing Additional Action if Needed	Very easy to implement additional action.	Very easy to implement additional action.	See Alternative 2.	See Alternative 2.
Ability to Monitor Effectiveness	Easily monitored during five-year site reviews.	Landfarming effectiveness will be determined through confirmatory sampling. MNA will be used to evaluate the groundwater quality. Easily monitored during five-year site reviews.	Landfarming effectiveness will be determined through confirmatory sampling. Easily monitored during five-year site reviews. LTM will also be used to evaluate the groundwater quality.	ORC barrier effectiveness will be determined through traditional sampling methods. LTM also will be used to evaluate groundwater quality. Easily monitored during five-year site reviews.
Cost				
Capital Cost	$0	$148,600	$307,000	$319,600
Annual O&M Cost	$2,000	$71,900	$75,600	$98,200
Present-Worth	$6,500	$1,341,400	$1,561,100	$1,948,600

Table 4-3
Analysis of Remedial Alternatives for Groundwater at SWMU 24

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls with LTM	Alternative 3 ORC, Institutional Controls with LTM
Overall Protection of Human Health and Environment			
Prevention of unacceptable risks to potential receptors to the groundwater	There is potential risk to receptors from the use of the groundwater as a potable residential water supply. Although potable use of the groundwater is unlikely, there would be no measures would be in place to prevent it.	There is potential risk to receptors from the use of the groundwater as a potable residential water supply. However, institutional controls would restrict residential potable use of the groundwater. LTM will detect any change in current groundwater concentrations and the potential for offsite migration.	See Alternative 2. In addition, because the use of the water table aquifer for potable water is unlikely, the benefit of potentially reducing contamination levels through ORC injection is not warranted.
Compliance with ARARs			
Chemical-Specific ARARs	ARARs (MCLs) and risk-based PRGs (where MCLs are not available) were established for contaminants of concern in groundwater. Since no action is taken, the PRGs would not be met.	Institutional controls at SWMU 24 would include restrictions on the use of groundwater as a potable residential water supply, therefore, PRGs would be met. LTM would track groundwater quality and the potential for offsite migration.	See Alternative 2. In addition, ORC application may reduce contaminant concentrations, however, with institutional controls in place, this may not be necessary. LTM would track groundwater quality and the potential for offsite migration.
Action-Specific ARARs	Not relevant.	Meets all action-specific ARARs.	Meets all action-specific ARARs.
Location-Specific ARARs	Not relevant.	Meets all location-specific ARARs.	Meets all location-specific ARARs.
Long Term Effectiveness and Permanence			
Groundwater	Source not remediated. Potential future risk posed by residential potable use of groundwater. No permanent means to prevent future exposure to groundwater in a manner that would result in unacceptable risks.	Source not remediated. Potential future risk posed by residential potable use of groundwater. Institutional controls and monitoring would be relied upon to eliminate unacceptable risks to groundwater.	See Alternative 2. In addition, source may be remediated through the use of ORC.

Table 4-3
Analysis of Remedial Alternatives for Groundwater at SWMU 24

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls with LTM	Alternative 3 ORC, Institutional Controls with LTM
Need for Five Year Review	Because contaminated groundwater remains onsite, five-year reviews would be required.	See Alternative 1.	See Alternative 1.
Reduction of Toxicity, Mobility, or Volume			
Groundwater	Toxicity and volume reduction of select contaminants of concern (DCE) may be reduced due by natural degradation.	See Alternative 1.	See Alternative 1.
Type and Quantity of Residuals Remaining After Remediation	No treatment undertaken. Therefore, groundwater contamination remains onsite.	No treatment undertaken. Groundwater contamination remains onsite.	Treatment consists of ORC. Depending on effectiveness of ORC, residual contamination may remain after remediation.
Short-Term Effectiveness			
Groundwater	Remedy implementation does not add to risk.	Remedy implementation does not add to risk.	A moderate amount of construction traffic will be associated with hauling material from offsite sources.
Time Until Action is Complete	Not applicable.	Annual long-term monitoring will occur as deemed necessary.	ORC insertion is expected to take effect in approximately four years. Annual long-term monitoring will continue as deemed necessary.
Implementability			
Ability to Construct and Operate	Not applicable.	Some construction required to install monitoring wells for LTM. Operation would consist of long-term monitoring. Groundwater use restrictions would require consent from base command.	The ORC injection would be performed using traditional direct-push methods. Operation would consist of ORC injection and long-term monitoring. Some construction required to install monitoring wells for LTM. Groundwater use restrictions would require consent from base command.

Table 4-3
Analysis of Remedial Alternatives for Groundwater at SWMU 24

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Institutional Controls with LTM	Alternative 3 ORC, Institutional Controls with LTM
Ease of Implementing Additional Action if Needed	Very easy to implement additional action.	See Alternative 1.	See Alternative 1.
Ability to Monitor Effectiveness	Easily monitored during five-year site reviews.	Easily monitored during five-year site reviews. LTM will also be used to evaluate the groundwater quality.	ORC effectiveness will be determined through traditional sampling methods. LTM also will be used to evaluate groundwater quality. Easily monitored during five-year site reviews.
Cost			
Capital Cost	$0	$242,100	$330,400
Annual O&M Cost	$2,000	$66,700	$66,700
Present-Worth	$6,500	$1,348,600	$1,686,200

5.0 Comparative Analysis and Recommended Alternative

A comparative analysis of remedial alternatives that leads to a recommended alternative is documented below for SWMUs 1, 15, and 24.

5.1 SWMU 1

The comparative analysis of proposed remedial alternatives and the recommended remedial alternative for SWMU 1 are documented below.

5.1.1 Comparative Analysis

The conclusions of the HHRA determined that there is unacceptable risk to potential future residential receptors at the site from potable use of groundwater from the water table aquifer at SWMU 1. However, the degree of this risk that may be attributed to site-related contamination has not been quantified because a background study has not been completed for NAS Oceana. In the following analysis, the sitewide remedial alternatives are evaluated in relation to one another. Keeping the potential risks in mind, the purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. The comparative analysis will focus on factors that provide distinctions between the alternatives.

The site-specific RAO for the protection of human health and the environment for SWMU 1 is:

- Prevent unacceptable risks to potential human receptors to the groundwater

The alternatives evaluated for SWMU 1 are:

- Alternative 1 – No Action
- Alternative 2 – Free-Product Removal, Institutional Controls, and Long-Term Monitoring
- Alternative 3 – Use of ORC, Free-Product Removal, Institutional Controls, and Long-Term Monitoring

Based on the findings of the HHRA, there is a potential future risk from potable use of groundwater at SWMU 1. As current receptors at the site are not residential users, the no action alternative presently prevents unacceptable risk, however, does not minimize future use of the groundwater. However, the long-term groundwater monitoring under Alternatives 2 and 3 would track groundwater quality and the potential for offsite plume migration, and the institutional controls would prohibit residential use of the groundwater. The free-product removal involved under Alternatives 2 and 3 will reduce contamination dissolution and migration and lower potential risk even further. Alternative 3 may reduce potential risk from groundwater faster than Alternative 2 through the application of an ORC

(a pilot study would be necessary to determine feasibility at the site). However, since residential use of the groundwater will be prohibited by implementation of institutional controls, the benefit of reducing contamination levels is small.

Under Alternative 1, the risk-based PRG of napthalene would be exceeded. The groundwater use restrictions under Alternatives 2 and 3 prevent the use of groundwater under SWMU 1 for residential use, therefore, the risk-based PRG would be met. The long-term monitoring involved in Alternatives 2 and 3 would track groundwater quality and the potential for offsite plume migration.

All three alternatives comply with the location-specific ARARs. According to federal regulatory agencies, no federally listed or proposed endangered species are known to exist on SWMU 1, except for transient individuals. Additionally, while there are wetlands located in areas surrounding SWMU 1, there are no federal or state regulated wetlands present within the boundaries of the site.

All alternatives comply with action-specific ARARs, including air discharge requirements, hazardous waste management requirements, and state stormwater management and erosion control requirements.

The present worth costs of Alternatives 2 and 3 are $1,617,700 and $2,067,300, respectively; Alternative 2 is more cost effective. All costs are within the degree of accuracy associated with a conceptual level cost estimate (+50% to -30% degree of accuracy). The cost estimate is provided in Appendix G.

5.1.2 Recommended Alternative

Alternative 2, Free-Product Removal and Institutional Controls with Long-term Monitoring, is the recommended alternative because it achieves the RAOs, meets the ARARs and to-be-considered criteria, guards against future risk, and is cost-effective. While Alternative 3 also meets the RAOs and ARARs, it is more costly and adds little to no benefit over Alternative 2. The use of groundwater at SWMU 1 is unlikely, therefore, the benefit of reducing contamination levels more rapidly through ORC is small. Alternative 1 currently meets the RAOs and ARARs, but does not provide for long-term groundwater quality tracking or guard against future use of groundwater. If, during the course of long-term monitoring, plume characteristics change (i.e. plume becomes larger and/or is shown to migrate offsite), Alternative 3 should be considered.

5.2 SWMU 15

The comparative analysis of proposed remedial alternatives and the recommended remedial alternative for SWMU 15 are documented below.

5.2.1 Comparative Analysis

The conclusions of the HHRA determined that there is unacceptable risk to industrial workers from surface soil under current scenarios, and to potential future residential receptors of the surface soil at the site. Based on the findings of the ERA, fifteen PAHs exceeded screening values resulting in HQs, ranging from 3.85 to 976, that need to be

addressed in the remedial alternatives for the SWMU in order to protect ecological receptors.

Unacceptable risks to human health were also determined from residential use of groundwater from the water table aquifer, and from non-consumptive contact with the groundwater caused by excavation into the water table aquifer at SWMU 15. However, the degree of this risk that may be attributed to site-related contamination has not been quantified because a background study has not been completed for NAS Oceana. Furthermore, the HHRA notes there are no industrial workers currently at the site and the site's future development by construction workers for residential purposes is highly unlikely.

In the following analysis, the sitewide remedial alternatives are evaluated in relation to one another. Keeping the potential risks in mind, the purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. The comparative analysis will focus on factors that provide distinctions between the alternatives.

The site-specific RAOs for the protection of human health and the environment for SWMU 15 are:

- Minimize direct contact of human receptors with surface soil that may pose unacceptable risks
- Minimize direct contact of ecological receptors with surface soil that may pose unacceptable risks
- Prevent unacceptable risks to potential human receptors to the groundwater (consumptive and non-consumptive)

The alternatives evaluated for SWMU 15 are:

- Alternative 1 – No Action
- Alternative 2 – Monitored Natural Attenuation, Institutional Controls, In-situ Soil Landfarming
- Alternative 3 – Long-Term Monitoring, Institutional Controls, In-situ Soil Landfarming
- Alternative 4 – Downgradient Reactive Curtain of ORC, Long-term Monitoring, Institutional Controls, In-situ Soil Landfarming

The no action alternative does not protect ecological receptors and does not protect current industrial and potential future residential human receptors from surface soil contamination. The landfarming in-situ soil remediation involved in Alternatives 2, 3, and 4 will reduce contamination levels to the PRGs identified in Section 2.3, protecting both current and future human receptors and ecological receptors.

Based on the findings of the HHRA, the current site conditions present a potential risk from residential use of groundwater at SWMU 15. The institutional controls involved in Alternatives 2, 3, and 4 guard would prohibit the residential use of the groundwater at the site. The residual NAPL is tied up in the low-permeability silt and clay, and is not likely to migrate. Under Alternative 2, the concentrations of these compounds dissolved in ground-

water may be reduced to concentrations below current regulatory guidelines long before adversely affecting potential downgradient receptors, however additional monitoring is required in order to effectively characterize the natural attenuation process. The long-term groundwater monitoring under Alternative 3 would track groundwater quality and the potential for offsite plume migration, and the institutional controls would prohibit residential use of the groundwater. Alternative 4 may reduce the potential risk of offsite migration through the application of an ORC, whereas Alternatives 1-3 would not. However, a pilot study would be required to determine site-specific feasibility, and application of this technology may not be warranted if the concentrations of dissolved contaminants in groundwater concentrations meet current regulatory guidelines before adversely affecting potential downgradient receptors.

No chemical-specific ARARs are available for contaminants in surface soil. Risk-based human health PRGs were calculated to set guidelines for the in-situ soil remediation through landfarming. The cleanup goal for protection of ecological receptors from total PAHs is 40 mg/kg. The individual human health risk-based PRGs will need to be met from implementation of the selected alternative to be protective of human health, and the total PAH cleanup goal will need to be met from implementation of the selected alternative to be protective of ecological receptors. Under Alternative 1, the human health and ecological soil cleanup levels would be exceeded, as well as the chemical-specific ARARs for drinking water (MCLs) and calculated risk-based PRGs for several volatile organic compounds and inorganics. The institutional controls under Alternatives 2, 3, and 4 prevent the residential use of groundwater under SWMU 15, therefore, the potential drinking water ARARs would be met. The in-situ landfarming under Alternatives 2, 3, and 4 will likely reduce contaminant levels to meet the cleanup levels for both human health and ecological receptors.

All three alternatives comply with the location-specific ARARs. According to federal regulatory agencies, no federally listed or proposed endangered species are known to exist on SWMU 15, except for transient individuals. Additionally, while there are wetlands located in areas surrounding SWMU 15, there are no federal or state regulated wetlands present within the boundaries of the site.

All alternatives comply with action-specific ARARs, including air discharge requirements, hazardous waste management requirements, and state stormwater management and erosion control requirements.

On a present worth basis, Alternatives 2 and 3 are more cost effective ($1,341,400 and $1,561,100, respectively) over Alternative 4 ($1,948,600). All costs are within the degree of accuracy associated with a conceptual level cost estimate (+50% to -30% degree of accuracy). The cost estimate is provided in Appendix G.

5.2.2 Recommended Alternative

Alternative 3, Long-Term Monitoring with Institutional Controls and Landfarming, is the recommended alternative because it achieves the remedial action objectives, meets the ARARs and to-be considered criteria, guards against future risk, and is cost-effective.

Alternative 1 does not meet the RAOs and ARARs, and does not provide for long-term groundwater quality tracking or guard against future risk. While Alternative 2 may be feasible, additional characterization is necessary to ensure feasibility of benzene concen-

tration reductions. Long-term monitoring with institutional controls under Alternative 3 is sufficient to guard against future risk of all the contaminants of concern. Alternative 4 may reduce the potential risk of offsite migration through the application of an ORC, whereas Alternatives 1-3 would not. However, a pilot study would be required to determine site-specific feasibility, and application of this technology may not be warranted if the concentrations of dissolved contaminants in groundwater concentrations meet current regulatory guidelines before adversely affecting potential downgradient receptors. In-situ landfarming under Alternatives 2, 3, and 4 will likely reduce contaminant levels to meet the cleanup levels for both human health and ecological receptors.

5.3 SWMU 24

The comparative analysis of proposed remedial alternatives and the recommended remedial alternative for SWMU 24 are documented below.

5.3.1 Comparative Analysis

The conclusions of the HHRA determined that there is unacceptable risk to potential future residential receptors at the site from potable use of groundwater from the water table aquifer at SWMU 24. However, the degree of this risk that may be attributed to site-related contamination has not been quantified because a background study has not been completed for NAS Oceana. In the following analysis, the sitewide remedial alternatives are evaluated in relation to one another. Keeping the potential risks in mind, the purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. The comparative analysis will focus on factors that provide distinctions between the alternatives.

The site-specific RAOs for the protection of human health and the environment for SWMU 24 are:

- Prevent unacceptable risks to potential human receptors to the groundwater

The alternatives evaluated for SWMU 24 are:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls, and Long-Term Monitoring
- Alternative 3 – Use of ORC, Institutional Controls, and Long-Term Monitoring

Based on the findings of the HHRA, the potential future site conditions present a risk from potable residential use of groundwater at SWMU 24. However, the implementation of long-term groundwater monitoring under Alternatives 2 and 3 would track groundwater quality and the potential for offsite plume migration, and institutional controls would prohibit residential potable use of the groundwater. Alternative 3 may reduce potential risk from groundwater faster than Alternative 2 through the use of an ORC. However, since potable residential use of the groundwater will be prohibited by the institutional controls, the benefit of reducing contamination levels through remediation is small.

Under Alternative 1, the chemical-specific ARARs for drinking water (MCLs) and risk-based PRGs for cis-1,2-dichloroethene and several inorganic compounds would be exceeded under a residential scenario. The institutional controls under Alternatives 2 and 3 prevent the use of groundwater under SWMU 24 as a drinking water supply, therefore, the potential

drinking water PRGs would be met. The long-term monitoring involved in Alternatives 2 and 3 would track groundwater quality and the potential for offsite plume migration.

All three alternatives comply with the location-specific ARARs. According to federal regulatory agencies, no federally listed or proposed endangered species are known to exist on SWMU 24, except for transient individuals. Additionally, while there are wetlands located in areas surrounding SWMU 24, there are no federal or state regulated wetlands present within the boundaries of the site.

All alternatives comply with action-specific ARARs, including air discharge requirements, hazardous waste management requirements, and state stormwater management and erosion control requirements.

On a present worth basis, Alternative 2 is more cost effective ($1,348,600) than Alternative 3 ($1,686,200). All costs are within the degree of accuracy associated with a conceptual level cost estimate (+50% to -30% degree of accuracy). The cost estimate is provided in Appendix G.

5.3.2 Recommended Alternative

Alternative 2, Institutional Controls with Long-term Monitoring, is the recommended alternative because it achieves the remedial action objectives, meets the ARARs and to-be-considered criteria, guards against future risk, and is cost-effective. While Alternative 3 also meets the RAOs and ARARs, it adds little to no benefit over Alternative 2 for a substantial additional cost. While Alternative 3 may reduce contamination levels faster than the natural degradation rate that controls DCE degradation, the lower permeability regions may not be as quickly influenced by the oxygen. Therefore, contamination in the sandy aquifer may be reduced more quickly, however, the less permeable contaminated zones may not be degraded as readily. In addition, the potable residential use of groundwater at SWMU 24 will be prohibited by implementation of institutional controls, therefore, the benefit of reducing contamination levels through remediation is small. Alternative 1 currently meets the RAOs and ARARs, but does not provide for long-term groundwater quality tracking or guard against future risk. If, during the course of long-term monitoring, plume characteristics change (i.e. plume becomes larger and/or is shown to migrate offsite), Alternative 3 should be considered.

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Appendix A
Excerpts from the CMS

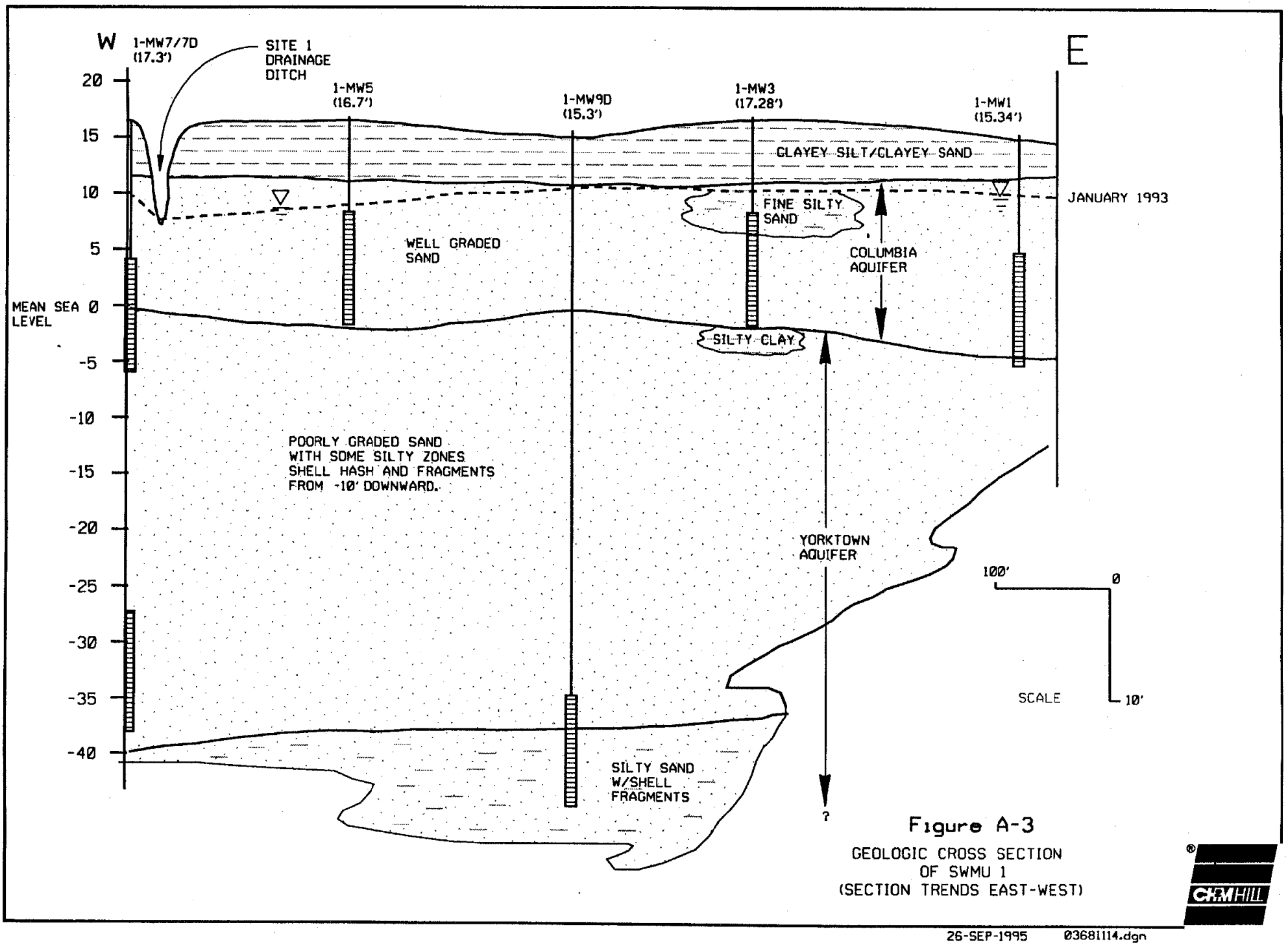
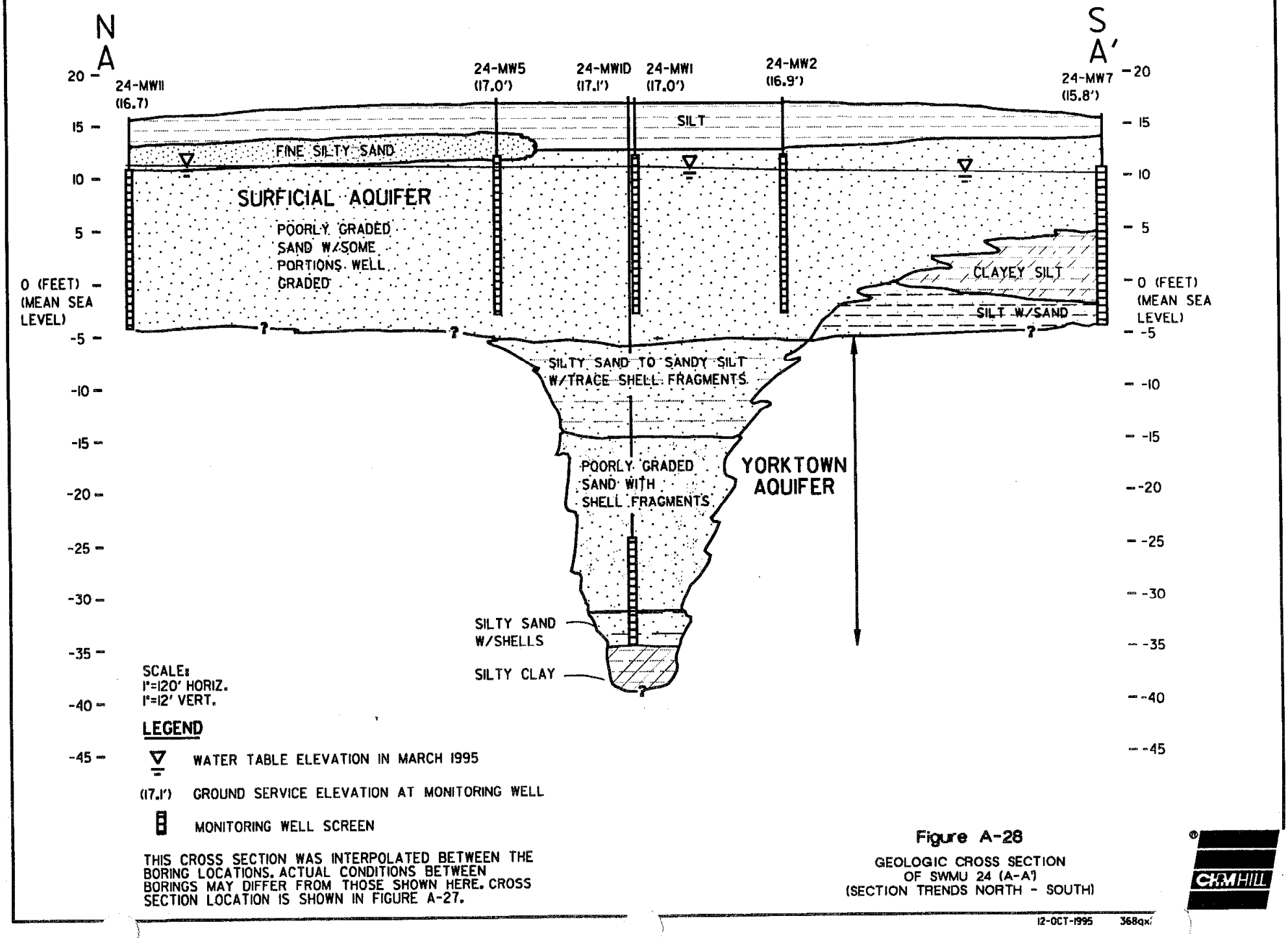


Figure A-3

GEOLOGIC CROSS SECTION
OF SWMU 1
(SECTION TRENDS EAST-WEST)

26-SEP-1995 03681114.dgn



SCALE:
1"=120' HORIZ.
1"=12' VERT.

LEGEND

▽ WATER TABLE ELEVATION IN MARCH 1995

(17.1') GROUND SERVICE ELEVATION AT MONITORING WELL

MONITORING WELL SCREEN

THIS CROSS SECTION WAS INTERPOLATED BETWEEN THE BORING LOCATIONS. ACTUAL CONDITIONS BETWEEN BORINGS MAY DIFFER FROM THOSE SHOWN HERE. CROSS SECTION LOCATION IS SHOWN IN FIGURE A-27.

Figure A-28

GEOLOGIC CROSS SECTION
OF SWMU 24 (A-A')
(SECTION TRENDS NORTH - SOUTH)

12-OCT-1995 368qx/

Appendix B
Final Technical Memorandum for the Groundwater Sampling at SWMU 1

Final

Technical Memorandum for the Groundwater Sampling at SWMU 1

Oceana Naval Air Station, Virginia Beach, Virginia

CTO Task Order - 055
January 2000

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

LANTDIV CLEAN II Program
Contract N62470-95-D-6007

Prepared by

CH2MHILL

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1.0 Introduction

This summary report documents the methods and results of groundwater sampling at SWMU 1. The field work was conducted during late October and early November 1998.

At SWMU 1 groundwater samples were collected from monitoring wells and select piezometers to assess site-wide groundwater quality. The purpose of the groundwater sampling at SWMU 1 was to support risk assessment.

This summary report was distributed as a final report in January, 2000. A couple of notes were added which addressed EPA comments on the draft-final report.

2.0 SWMU 1 Groundwater Sampling

Groundwater sampling activities at SWMU-1 were conducted by CH2M HILL, Inc., on November 5 - 9, 1998, to support risk assessment as requested by the USEPA in October 1998. Prior to this sampling event, groundwater at SWMU-1 had been sampled as part of the Corrective Measure Study conducted in 1994.

2.1 Groundwater Sampling Procedures for Monitoring Wells and Piezometers

On November 5 - 9, 1998, groundwater samples were collected from 10 groundwater monitoring wells (MW02 through MW07, MW7D, MW8, MW8D, and MW10) and five piezometers (PZ01 through PZ05) at SWMU-1. These groundwater sampling locations are illustrated in Figure 2-1. Groundwater samples were not collected from monitoring wells MW01 and MW09 since these wells could not be located in the field.

All groundwater samples were collected using a low-flow Grundfos pump with dedicated tubing in accordance with CH2M HILL, Inc.'s standard operating procedures (SOPs) for groundwater sampling. Upon collection, all groundwater samples were submitted to an offsite laboratory (GP Environmental of Gaithersburg, MD) for analysis of Target Compound List (TCL) Low-concentration (LC) Volatile Organic Compounds (VOCs), Polyaromatic Hydrocarbons (PAHs) by EPA Method 8310 and Total Petroleum Hydrocarbons (TPH). These analyses were chosen based upon discussions with the EPA during the October 1998 meeting just prior to the fieldwork, to confirm the presence or absence of potential groundwater contaminants and to support a human health risk assessment of this site.

2.1.1 Other Sampling

In addition to the groundwater samples collected at SWMU-1, an attempt was made to collect free product samples from piezometers PZ03 and PZ05; monitoring wells MW04 and MW05; and two skimmer tanks located at SWMU-1.

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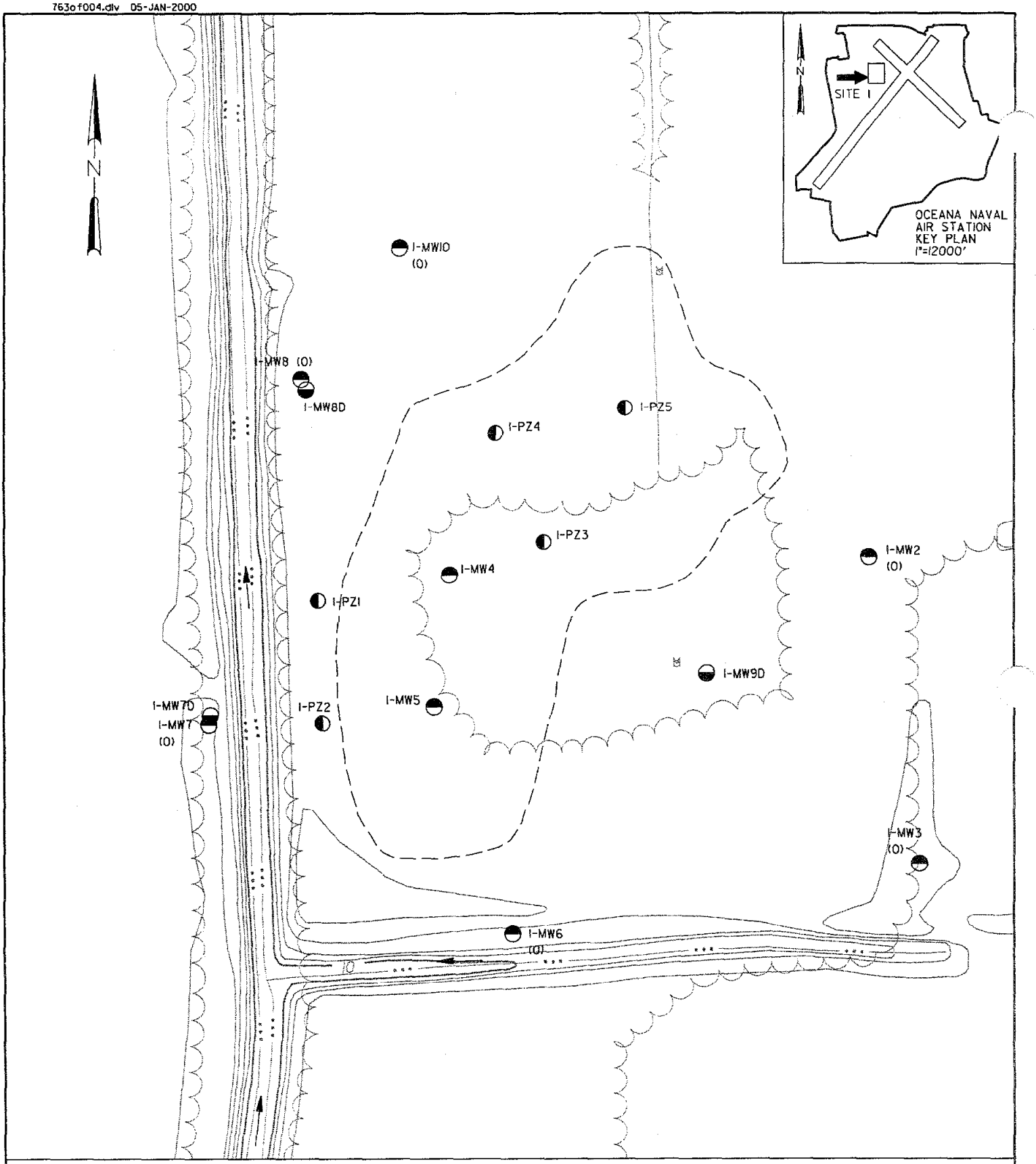

LEGEND

- SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- SHALLOW PIEZOMETER
- DIRECTION OF SURFACE WATER FLOW
- ESTIMAYED LIMIT OF FREE PRODUCT (BASED ON TEST PITS AND BORINGS)

0 50 100 150
SCALE IN FEET

Figure 2-
GROUNDWATER SAMPLING LOCATIONS AT SWMU 1
Naval Air Station, Oceana
Virginia Beach, Virginia

CH2MHILL

Specifically, two solar powered product skimmers remove product from the surface of the water table in piezometers PZ03 and PZ05, and monitoring wells MW04 and MW05. One of these skimmers is shared by piezometers PZ03 and PZ05, and the other skimmer is shared by monitoring wells MW04 and MW05. These skimmers are programmed to remove any free product present in these piezometers and monitoring wells on a daily basis, and to deposit the product into the skimmer tanks. Therefore, no product was available from the piezometers and monitoring wells.

Although the down-well screens of the skimmers are hydrophobic, only a small amount of product was present in the skimmer tanks at the time the groundwater samples were collected in November 1998. Most of the liquid in the tank was water. Since a sufficient volume of free product could not be collected to fulfill volume requirements for the sampling, no product sample was submitted for off-site laboratory analysis. At this time, the skimmers within each of the two piezometers and monitoring wells have been turned off.

On March 11, 19989 product accumulating in well MW04 was sampled and produced a sufficient volume for collection. The product was fingerprinted with a total petroleum hydrocarbon diesel and gasoline-range organics analysis to identify the nature of it. The product is identified as degraded diesel fuel. The product was also analyzed for TCL volatiles and semi volatiles. The results of these analyses will be incorporated in the site-wide human health risk assessment of SWMU 01.

2.2 Groundwater Sampling Results

Sampling results for the November 1998 groundwater sampling activities at SWMU-1 are documented below. The detected chemicals from the SWMU 1 validated analytical groundwater data are located in Appendix A-1.

2.2.1 SWMU-1 Groundwater Sampling Results

Fifteen groundwater samples were analyzed for TCL low concentration VOCs, low concentration PAHs, and TPH. CH2M HILL compared the groundwater analytical results to the EPA Region III RBC screening levels for tap water and EPA MCLs for drinking water. Figure 2-2 illustrates the locations where the detected chemical concentrations exceeded

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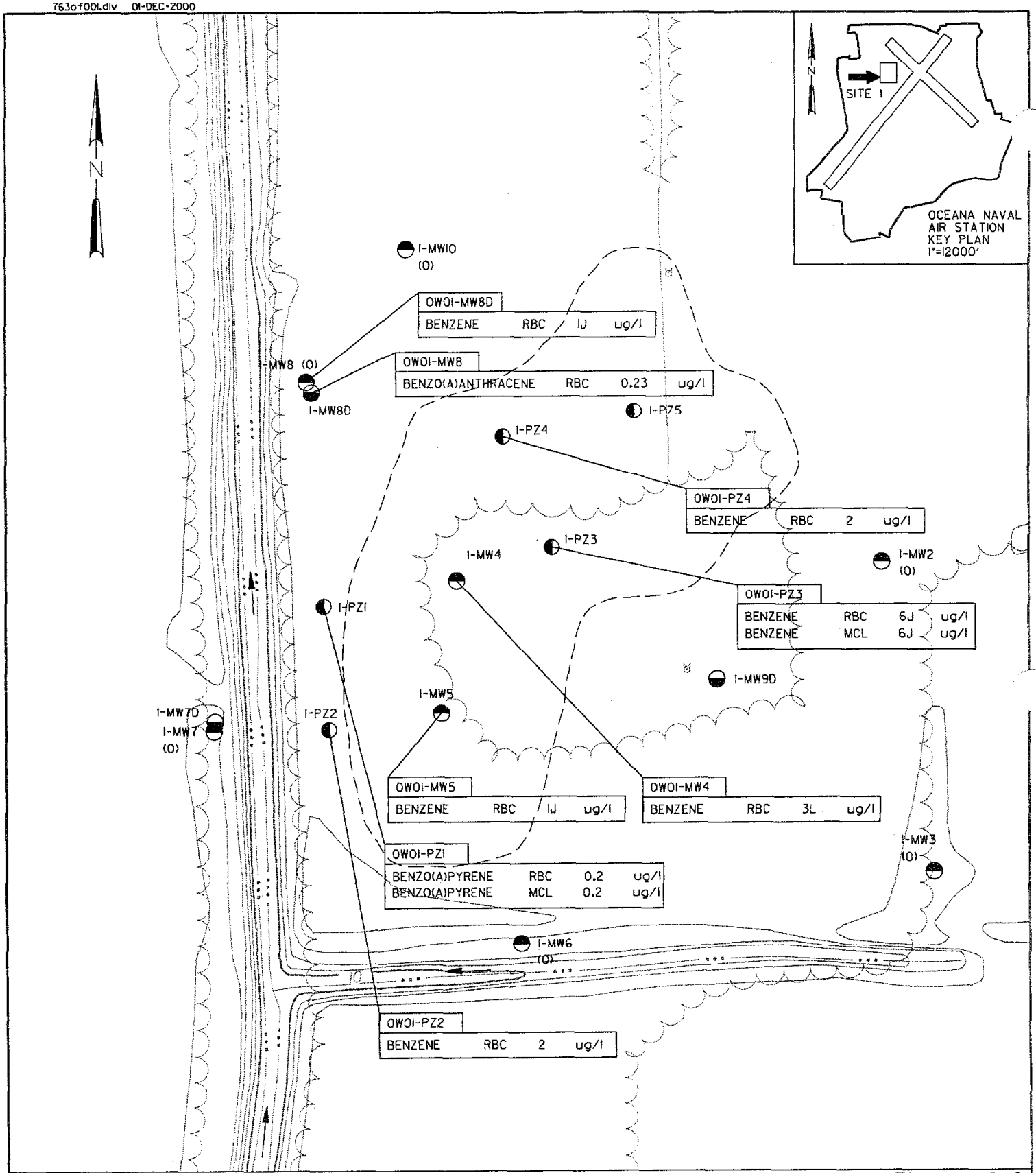

Figure 2-2
CHEMICALS DETECTED IN GROUNDWATER THAT EXCEED EPA REGION III RBC SCREENING LEVELS FOR TAP WATER OR EPA MCLs FOR DRINKING WATER AT SWMU 1 - NOVEMBER 1998
Naval Air Station, Oceana
Virginia Beach, Virginia

LEGEND
- SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- SHALLOW PIEZOMETER
- DIRECTION OF SURFACE WATER FLOW
- ESTIMAYED LIMIT OF FREE PRODUCT (BASED ON TEST PITS AND BORINGS)

0 50 100 150
SCALE IN FEET

CH2MHILL

screening levels or regulatory standards. Where a chemical concentration exceeded more than one screening level or regulatory standard, exceedances were posted labeled. Table 2-1 lists the location of the exceeding detections, sample collection date, chemicals that exceeded screening limits, the analytical results, any data validation qualifiers, the detection limits, the screening levels or regulatory standards, and the exceedance quotients. The exceedance quotient is the detected concentration divided by the regulatory limit. It serves as a quick assessment of the degree to which specific chemicals exceed regulatory limits. Where a chemical exceeded more than one screening level or regulatory standard, both were tabulated.

Chemicals with non-detect values but have detection limits that exceeded regulatory screening limits for EPA Region III RBC screening levels for tap water or and EPA MCLs for drinking water are tabulated in Appendix A-2.

In summary, benzene, benzo(a)anthracene and benzo(a)pyrene concentrations exceeded groundwater regulatory criteria at SWMU-1. Specifically, benzene concentrations exceeded the Region III RBC for tap water in samples MW04, MW05, MW8, PZ02, PZ03 and PZ04 at 3 ug/l, 1 ug/l, 1 ug/l, 1 ug/l, 6 ug/l, and 2 ug/l, respectively. The benzene concentration in sample PZ03 (6 ug/l) also exceeded the MCL. The benzo(a)anthracene concentration of 0.23 ug/L exceeded the RBC in the sample from monitoring well MW8D. Finally, benzo(a)pyrene was detected in the sample from PZ01 at 0.2 ug/l, and exceeded both the RBC and the MCL.

Table 2-1
Groundwater Exceedances of Regulatory Limits and Screening Levels
SWMU-1, Oceana Naval Air Station, Virginia Beach, Virginia

Sample ID	Sample Location	Date Sample Collected	Analyte	Analytical Value (µg/L)	Data Validation Qualifier	Detection Limit (µg/L)	Regulatory Criteria	Regulatory Criteria Value (µg/L)	Exceedance Quotient[1]
OW01-MW04-R01	01-MW04	11/09/1998	Benzene	3	L	5	RBC Tap Water	0.36	8.3
OW01-MW05-R01	01-MW05	11/09/1998	Benzene	1	J	1	RBC Tap Water	0.36	2.8
OW1-MW08D-R01	01-MW8D	11/05/1998	Benzo(a)anthracene	0.23		0.05	RBC Tap Water	0.092	2.5
OW1-MW08-R01	01-MW8	11/05/1998	Benzene	1	J	1	RBC Tap Water	0.36	2.8
OW1-PZ01-R01	01-PZ1	11/05/1998	Benzo(a)pyrene	0.2		0.1	RBC Tap Water	0.0092	21.7
							MCL	0.2	1.0
OW1-PZ02-R01	01-PZ2	11/05/1998	Benzene	1		1	RBC Tap Water	0.36	2.8
OW01-PZ03-R01	01-PZ3	11/09/1998	Benzene	6	J	10	RBC Tap Water	0.36	16.7
							MCL	5	1.2
OW01-PZ04-R01	01-PZ4	11/09/1998	Benzene	2		1	RBC Tap Water	0.36	5.6

Notes:
L - Biased Low
J - Estimated
RBC Tap Water - EPA Region III Risk-Based Concentration for Tap Water
MCL - Maximum Concentration Limit
[1]Exceedance Quotient is calculated as follows: Analytical Value/Regulatory Criteria Value

3.0 Conclusions and Recommendations

This section documents conclusions and recommendations for the SWMU 01 monitoring well groundwater sampling.

3.1 Conclusions

Results of the SWMU 01 groundwater sampling indicate that the shallow groundwater contains low concentrations of benzene and one PAH, specifically benzo(a)pyrene, at concentrations that exceed MCLs and RBCs for tap water. Well MW8D, screened from 45-55 feet bgs, contains benzo(a)anthracene at an estimated concentration (J-flagged) of 1 µg/L that exceeds the RBC for tap water. The product present in well MW04 is tentatively identified as degraded diesel fuel.

3.2 Recommendations

Since benzene and benzo(a)pyrene were detected in shallow monitoring wells adjacent to the surface water drainage ditch the Navy recommends that four sampling locations along the reach of the drainage ditch be sampled for sediment and surface water. The proposed sample locations are illustrated on Figure 3-1 and include upgradient and downgradient sample locations. The Navy will analyze the samples for low concentration VOCs, low concentration PAHs, and TPH. These data will be utilized in the proposed human health risk assessment for SWMU 1 to determine if the low concentrations of benzene and benzo(a)pyrene in the shallow groundwater are impacting the surface water in the drainage ditch adjacent to the site. For use in the proposed ecological risk assessment, these sampling results will be compared to the BTAG screening levels.

On July 22, 1999 the sediment and surface water was sampled as documented above and depicted on Figure 3-1. The analytical results will be included in both the site-wide human health risk assessment and the ecological risk assessment as documented below.

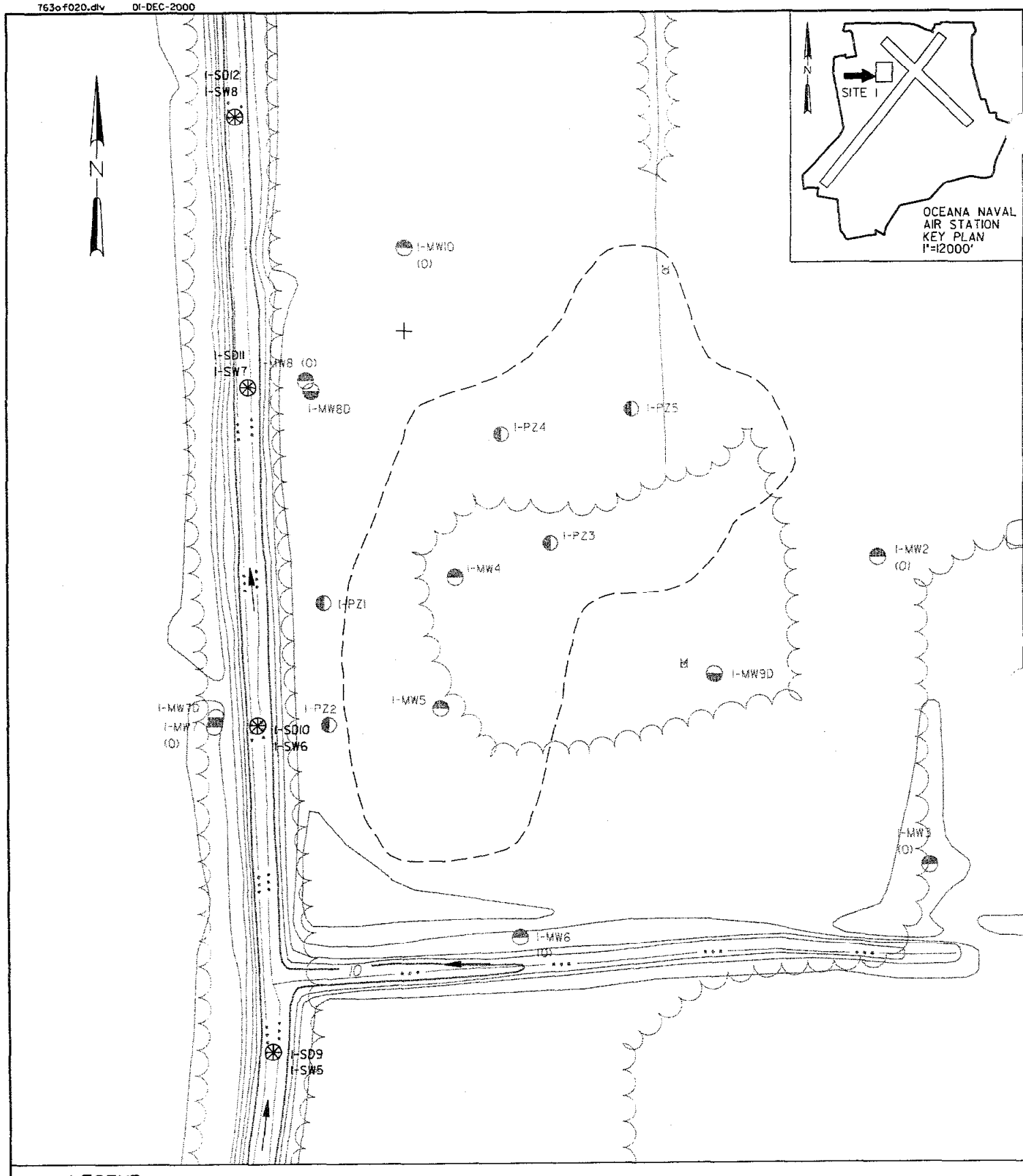

Figure 3-
PROPOSED SEDIMENT & SURFACE SAMPLING LOCATIONS AT SWMU 1
Naval Air Station, Oceana
Virginia Beach, Virginia
CH2MHILL

3.2.1 Future Plans

The Navy will prepare human health risk assessment assumptions for SWMU 01 to facilitate the assessment of site-wide groundwater sampling results. The assumptions for use in the human health risk assessment will be forwarded to the EPA program toxicologist for approval. Prior to proceeding with the risk assessment the Navy proposes to meet with the EPA and VADEQ to determine what additional data might be required in order to complete the risk assessment.

The Navy will also provide a conceptual ecological model of SWMU 01 that includes physiography and proposed future land use surrounding the site. The model will be used to evaluate any potential pathways for ecological receptors and to support a management decision pertaining to ecological risks at SWMU 1. Results of the proposed sediment and surface water sampling and the comparison of these results to the BTAG Screening Levels will be included with the conceptual ecological model. In addition, a summary of results for the NASO stormwater monitoring program for the SWMU 1 area will also be included.

The Navy will conduct a human health risk assessment. Upon completion of the risk assessment the Navy will proceed with a Focused Feasibility Study (FFS) for SWMU 1. Once a remedial alternative is selected in the FFS the Navy will prepare a Proposed Remedial Action Plan (PRAP) and a record of decision (ROD).

Appendix A-1
Summary of Detected Chemicals for Groundwater Sampling at SWMU 1

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW01-MW02-R01	11/09/1998	ANTHRACENE	0.0640	B	UG/L	0.1100
OW01-MW02-R01	11/09/1998	NAPHTHALENE	0.0790	B	UG/L	2.2000
OW01-MW02-R01	11/09/1998	PHENANTHRENE	0.0610	B	UG/L	0.0540
OW01-MW02-R01	11/09/1998	PYRENE	0.0030	J	UG/L	0.0050
OW01-MW02-R01	11/09/1998	TOTAL PETROLEUM HYDROCARBONS	1.2200	B	MG/L	0.5000
OW01-MW02-R01	11/09/1998	TRICHLOROETHENE	1.0000	J	UG/L	1.0000
OW01-MW03-R01	11/09/1998	ANTHRACENE	0.0740	B	UG/L	0.1000
OW01-MW03-R01	11/09/1998	FLUORANTHENE	2.1000	B	UG/L	1.0000
OW01-MW03-R01	11/09/1998	PHENANTHRENE	0.0180	B	UG/L	0.0500
OW01-MW03-R01	11/09/1998	PYRENE	0.0050		UG/L	0.0050
OW01-MW04P-R01	11/09/1998	ACENAPHTHENE	24.0000	B	UG/L	22.0000
OW01-MW04P-R01	11/09/1998	ANTHRACENE	3.5000	B	UG/L	11.0000
OW01-MW04P-R01	11/09/1998	CHLOROFORM	9.0000	B	UG/L	10.0000
OW01-MW04P-R01	11/09/1998	FLUORANTHENE	180.0000	B	UG/L	110.0000
OW01-MW04P-R01	11/09/1998	FLUORENE	120.0000	B	UG/L	43.0000
OW01-MW04P-R01	11/09/1998	ISOPROPYLBENZENE	7.0000	J	UG/L	10.0000
OW01-MW04P-R01	11/09/1998	M&P-XYLENE	12.0000		UG/L	10.0000
OW01-MW04P-R01	11/09/1998	METHYLENE CHLORIDE	8.0000	B	UG/L	10.0000
OW01-MW04P-R01	11/09/1998	NAPHTHALENE	110.0000	B	UG/L	220.0000
OW01-MW04P-R01	11/09/1998	NAPHTHALENE	208.0000		UG/L	10.0000
OW01-MW04P-R01	11/09/1998	N-PROPYLBENZENE	10.0000		UG/L	10.0000
OW01-MW04P-R01	11/09/1998	PHENANTHRENE	7.1000	B	UG/L	5.4000
OW01-MW04P-R01	11/09/1998	TOTAL PETROLEUM HYDROCARBONS	52.2000		MG/L	5.0000
OW01-MW04-R01	11/09/1998	1,3,5-TRIMETHYLBENZENE	5.0000	L	UG/L	5.0000
OW01-MW04-R01	11/09/1998	ACENAPHTHENE	36.0000	B	UG/L	21.0000
OW01-MW04-R01	11/09/1998	ANTHRACENE	9.2000	B	UG/L	11.0000
OW01-MW04-R01	11/09/1998	BENZENE	3.0000	L	UG/L	5.0000
OW01-MW04-R01	11/09/1998	CHLOROFORM	5.0000	B	UG/L	5.0000
OW01-MW04-R01	11/09/1998	FLUORANTHENE	530.0000	B	UG/L	110.0000
OW01-MW04-R01	11/09/1998	FLUORENE	180.0000	B	UG/L	42.0000
OW01-MW04-R01	11/09/1998	ISOPROPYLBENZENE	5.0000	L	UG/L	5.0000
OW01-MW04-R01	11/09/1998	M&P-XYLENE	9.0000	L	UG/L	5.0000
OW01-MW04-R01	11/09/1998	METHYLENE CHLORIDE	4.0000	B	UG/L	5.0000
OW01-MW04-R01	11/09/1998	NAPHTHALENE	150.0000	B	UG/L	210.0000
OW01-MW04-R01	11/09/1998	NAPHTHALENE	179.0000	L	UG/L	5.0000
OW01-MW04-R01	11/09/1998	N-PROPYLBENZENE	7.0000	L	UG/L	5.0000
OW01-MW04-R01	11/09/1998	PHENANTHRENE	18.0000	B	UG/L	5.3000
OW01-MW04-R01	11/09/1998	PYRENE	0.2300	J	UG/L	0.5300
OW01-MW04-R01	11/09/1998	TOTAL PETROLEUM HYDROCARBONS	24.1000		MG/L	2.5800
OW01-MW05-R01	11/09/1998	ACENAPHTHENE	14.0000	B	UG/L	4.2000
OW01-MW05-R01	11/09/1998	ANTHRACENE	3.7000	B	UG/L	2.1000
OW01-MW05-R01	11/09/1998	BENZENE	1.0000	J	UG/L	1.0000
OW01-MW05-R01	11/09/1998	FLUORANTHENE	180.0000	B	UG/L	21.0000
OW01-MW05-R01	11/09/1998	FLUORENE	32.0000	B	UG/L	8.3000
OW01-MW05-R01	11/09/1998	ISOPROPYLBENZENE	1.0000		UG/L	1.0000
OW01-MW05-R01	11/09/1998	M&P-XYLENE	2.0000		UG/L	1.0000
OW01-MW05-R01	11/09/1998	NAPHTHALENE	58.0000	B	UG/L	42.0000
OW01-MW05-R01	11/09/1998	NAPHTHALENE	58.0000		UG/L	1.0000
OW01-MW05-R01	11/09/1998	PHENANTHRENE	7.8000	B	UG/L	1.0000
OW01-MW05-R01	11/09/1998	PYRENE	0.0370	J	UG/L	0.1000
OW01-MW05-R01	11/09/1998	TOTAL PETROLEUM HYDROCARBONS	5.7000	B	MG/L	0.5210
OW01-PZ03-R01	11/09/1998	ACENAPHTHENE	9.2000	B	UG/L	2.1000
OW01-PZ03-R01	11/09/1998	ANTHRACENE	1.6000	B	UG/L	1.1000
OW01-PZ03-R01	11/09/1998	BENZENE	6.0000	J	UG/L	10.0000
OW01-PZ03-R01	11/09/1998	CHLOROFORM	9.0000	B	UG/L	10.0000
OW01-PZ03-R01	11/09/1998	ETHYLBENZENE	17.0000		UG/L	10.0000
OW01-PZ03-R01	11/09/1998	FLUORANTHENE	85.0000	B	UG/L	11.0000
OW01-PZ03-R01	11/09/1998	FLUORENE	45.0000	B	UG/L	4.2000
OW01-PZ03-R01	11/09/1998	M&P-XYLENE	66.0000		UG/L	10.0000
OW01-PZ03-R01	11/09/1998	METHYLENE CHLORIDE	7.0000	B	UG/L	10.0000
OW01-PZ03-R01	11/09/1998	NAPHTHALENE	57.0000		UG/L	21.0000
OW01-PZ03-R01	11/09/1998	O-XYLENE	11.0000		UG/L	10.0000
OW01-PZ03-R01	11/09/1998	PHENANTHRENE	2.5000	B	UG/L	0.5300
OW01-PZ03-R01	11/09/1998	TOLUENE	35.0000		UG/L	10.0000
OW01-PZ03-R01	11/09/1998	TOTAL PETROLEUM HYDROCARBONS	2.3100	B	MG/L	0.5320

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW01-PZ04-R01	11/09/1998	1,1-DICHLOROETHANE	1.0000	J	UG/L	1.0000
OW01-PZ04-R01	11/09/1998	4-ISOPROPYLTOLUENE	2.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	ACENAPHTHENE	3.1000	B	UG/L	1.1000
OW01-PZ04-R01	11/09/1998	ANTHRACENE	0.6200	B	UG/L	0.5300
OW01-PZ04-R01	11/09/1998	BENZENE	2.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	ETHYLBENZENE	6.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	FLUORANTHENE	31.0000	B	UG/L	5.3000
OW01-PZ04-R01	11/09/1998	FLUORENE	17.0000	B	UG/L	2.1000
OW01-PZ04-R01	11/09/1998	ISOPROPYLBENZENE	1.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	M&P-XYLENE	12.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	NAPHTHALENE	16.0000	B	UG/L	11.0000
OW01-PZ04-R01	11/09/1998	NAPHTHALENE	22.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	N-PROPYLBENZENE	2.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	O-XYLENE	4.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	PHENANTHRENE	0.9800	B	UG/L	0.2700
OW01-PZ04-R01	11/09/1998	TOLUENE	9.0000		UG/L	1.0000
OW01-PZ04-R01	11/09/1998	TOTAL PETROLEUM HYDROCARBONS	1.1200	B	MG/L	0.5380
OW01-PZ05-R01	11/09/1998	4-ISOPROPYLTOLUENE	1.0000		UG/L	1.0000
OW01-PZ05-R01	11/09/1998	ACENAPHTHENE	0.2400	B	UG/L	0.2000
OW01-PZ05-R01	11/09/1998	ANTHRACENE	0.1600	B	UG/L	0.1000
OW01-PZ05-R01	11/09/1998	ETHYLBENZENE	4.0000		UG/L	1.0000
OW01-PZ05-R01	11/09/1998	FLUORANTHENE	8.6000	B	UG/L	1.0000
OW01-PZ05-R01	11/09/1998	FLUORENE	0.6600	B	UG/L	0.4100
OW01-PZ05-R01	11/09/1998	ISOPROPYLBENZENE	1.0000	J	UG/L	1.0000
OW01-PZ05-R01	11/09/1998	M&P-XYLENE	7.0000		UG/L	1.0000
OW01-PZ05-R01	11/09/1998	NAPHTHALENE	0.8900	B	UG/L	2.0000
OW01-PZ05-R01	11/09/1998	NAPHTHALENE	13.0000		UG/L	1.0000
OW01-PZ05-R01	11/09/1998	O-XYLENE	1.0000	J	UG/L	1.0000
OW01-PZ05-R01	11/09/1998	PHENANTHRENE	0.0520	B	UG/L	0.0510
OW01-PZ05-R01	11/09/1998	PYRENE	0.0020	J	UG/L	0.0050
OW01-PZ05-R01	11/09/1998	TOLUENE	1.0000	J	UG/L	1.0000
OW01-PZ05-R01	11/09/1998	TOTAL PETROLEUM HYDROCARBONS	0.6410	B	MG/L	0.5150
OW1-MW10-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-MW10-R01	11/05/1998	NAPHTHALENE	0.2100	J	UG/L	2.2000
OW1-MW10-R01	11/05/1998	PHENANTHRENE	0.0210	B	UG/L	0.0560
OW1-MW10-R01	11/05/1998	TOTAL PETROLEUM HYDROCARBONS	1.6900		MG/L	0.5000
OW1-MW10-R01	11/05/1998	TRICHLOROETHENE	1.0000	J	UG/L	1.0000
OW1-MW6-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-MW6-R01	11/05/1998	PHENANTHRENE	0.0120	B	UG/L	0.0520
OW1-MW6-R01	11/05/1998	PYRENE	0.0050		UG/L	0.0050
OW1-MW6-R01	11/05/1998	TOTAL PETROLEUM HYDROCARBONS	2.1400		MG/L	0.5490
OW1-MW7D-R01	11/05/1998	ANTHRACENE	0.9200	B	UG/L	0.1000
OW1-MW7D-R01	11/05/1998	FLUORANTHENE	2.4000		UG/L	1.0000
OW1-MW7D-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-MW7D-R01	11/05/1998	PHENANTHRENE	0.3500		UG/L	0.0520
OW1-MW7-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-MW7-R01	11/05/1998	PHENANTHRENE	0.0140	B	UG/L	0.0520
OW1-MW7-R01	11/05/1998	PYRENE	0.0020	J	UG/L	0.0050
OW1-MW8D-R01	11/05/1998	ANTHRACENE	0.3600	B	UG/L	0.5000
OW1-MW8D-R01	11/05/1998	BENZO(A)ANTHRACENE	0.2300		UG/L	0.0500
OW1-MW8D-R01	11/05/1998	FLUORANTHENE	6.5000		UG/L	5.0000
OW1-MW8D-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-MW8D-R01	11/05/1998	PYRENE	0.0100	J	UG/L	0.0300
OW1-MW8D-R01	11/05/1998	TOTAL PETROLEUM HYDROCARBONS	1.8100		MG/L	0.5050
OW1-MW8-R01	11/05/1998	BENZENE	1.0000	J	UG/L	1.0000
OW1-MW8-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-MW8-R01	11/05/1998	NAPHTHALENE	0.6200	J	UG/L	2.0000
OW1-MW8-R01	11/05/1998	PHENANTHRENE	0.0160	B	UG/L	0.0510
OW1-PZ1-R01	11/05/1998	ACENAPHTHENE	0.1300	J	UG/L	0.2100
OW1-PZ1-R01	11/05/1998	ANTHRACENE	0.2200	B	UG/L	0.1000
OW1-PZ1-R01	11/05/1998	BENZO(A)PYRENE	0.2000		UG/L	0.1000
OW1-PZ1-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-PZ1-R01	11/05/1998	NAPHTHALENE	1.7000	J	UG/L	2.1000
OW1-PZ1-R01	11/05/1998	PYRENE	0.0030	J	UG/L	0.0050
OW1-PZ1-R01	11/05/1998	SEC-BUTYLBENZENE	2.0000		UG/L	1.0000

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW1-PZ1-R01	11/05/1998	TOTAL PETROLEUM HYDROCARBONS	0.8750	B	MG/L	0.5050
OW1-PZ2P-R01	11/05/1998	ACENAPHTHENE	0.0960	J	UG/L	0.2000
OW1-PZ2P-R01	11/05/1998	ANTHRACENE	0.3500	B	UG/L	0.1000
OW1-PZ2P-R01	11/05/1998	BENZENE	1.0000		UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	FLUORANTHENE	2.3000		UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	ISOPROPYLBENZENE	4.0000		UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	M&P-XYLENE	1.0000	J	UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	NAPHTHALENE	6.6000		UG/L	2.0000
OW1-PZ2P-R01	11/05/1998	NAPHTHALENE	22.0000		UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	N-PROPYLBENZENE	5.0000		UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	SEC-BUTYLBENZENE	5.0000		UG/L	1.0000
OW1-PZ2P-R01	11/05/1998	TOTAL PETROLEUM HYDROCARBONS	1.1200	B	MG/L	0.6100
OW1-PZ2-R01	11/05/1998	1,3,5-TRIMETHYLBENZENE	3.0000		UG/L	1.0000
OW1-PZ2-R01	11/05/1998	ACENAPHTHENE	0.1500	J	UG/L	0.2100
OW1-PZ2-R01	11/05/1998	ANTHRACENE	0.8500	B	UG/L	0.1100
OW1-PZ2-R01	11/05/1998	BENZENE	1.0000		UG/L	1.0000
OW1-PZ2-R01	11/05/1998	FLUORANTHENE	6.2000		UG/L	1.1000
OW1-PZ2-R01	11/05/1998	ISOPROPYLBENZENE	3.0000		UG/L	1.0000
OW1-PZ2-R01	11/05/1998	M&P-XYLENE	1.0000	J	UG/L	1.0000
OW1-PZ2-R01	11/05/1998	METHYLENE CHLORIDE	1.0000	B	UG/L	1.0000
OW1-PZ2-R01	11/05/1998	NAPHTHALENE	14.0000		UG/L	2.1000
OW1-PZ2-R01	11/05/1998	NAPHTHALENE	18.0000		UG/L	1.0000
OW1-PZ2-R01	11/05/1998	N-PROPYLBENZENE	4.0000		UG/L	1.0000
OW1-PZ2-R01	11/05/1998	SEC-BUTYLBENZENE	4.0000		UG/L	1.0000
OW1-PZ2-R01	11/05/1998	TOTAL PETROLEUM HYDROCARBONS	1.9000		MG/L	0.5000

Notes:
B = Chemical found in the sample at levels nearly equivalent to the blank
K = Biased high so actual value is possbley lower
L = Biased low and actual value possibly higher

Appendix A-2
Summary of Non-Detected Chemicals in SWMU 1 Groundwater Where the Detection Limit Exceeded the Screening Level or MCL

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW01-MW02-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-MW02-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW01-MW03-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-MW03-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW01-MW04P-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-MW04P-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	7	MCL	1.4
OW01-MW04P-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	7	RBC Tap	1.4
OW01-MW04P-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.05	MCL	200.0
OW01-MW04P-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.05	RBC Tap	200.0
OW01-MW04P-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-MW04P-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-MW04P-R01	BENZENE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	BENZENE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-MW04P-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.2	MCL	55.0
OW01-MW04P-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.2	RBC Tap	55.0
OW01-MW04P-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-MW04P-R01	TETRACHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	TETRACHLOROETHENE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-MW04P-R01	TRICHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	TRICHLOROETHENE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-MW04P-R01	VINYL CHLORIDE	10	U	UG/L	10	2	MCL	5.0
OW01-MW04P-R01	VINYL CHLORIDE	10	U	UG/L	10	2	RBC Tap	5.0
OW01-MW04-R01	1,1,2-TRICHLOROETHANE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	1,1,2-TRICHLOROETHANE	5	UL	UG/L	5	5	RBC Tap	1.0
OW01-MW04-R01	1,2-DIBROMOETHANE	5	UL	UG/L	5	0.05	MCL	100.0
OW01-MW04-R01	1,2-DIBROMOETHANE	5	UL	UG/L	5	0.05	RBC Tap	100.0
OW01-MW04-R01	1,2-DICHLOROETHANE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	1,2-DICHLOROETHANE	5	UL	UG/L	5	5	RBC Tap	1.0
OW01-MW04-R01	1,2-DICHLOROPROPANE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	1,2-DICHLOROPROPANE	5	UL	UG/L	5	5	RBC Tap	1.0
OW01-MW04-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.2	MCL	55.0
OW01-MW04-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.2	RBC Tap	55.0
OW01-MW04-R01	CARBON TETRACHLORIDE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	CARBON TETRACHLORIDE	5	UL	UG/L	5	5	RBC Tap	1.0
OW01-MW04-R01	TETRACHLOROETHENE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	TETRACHLOROETHENE	5	UL	UG/L	5	5	RBC Tap	1.0
OW01-MW04-R01	TRICHLOROETHENE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	TRICHLOROETHENE	5	UL	UG/L	5	5	RBC Tap	1.0
OW01-MW04-R01	VINYL CHLORIDE	5	UL	UG/L	5	2	MCL	2.5
OW01-MW04-R01	VINYL CHLORIDE	5	UL	UG/L	5	2	RBC Tap	2.5
OW01-MW05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-MW05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW01-MW05-R01	BENZO(A)PYRENE	2.1	U	UG/L	2.1	0.2	MCL	10.5
OW01-MW05-R01	BENZO(A)PYRENE	2.1	U	UG/L	2.1	0.2	RBC Tap	10.5
OW01-PZ03-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-PZ03-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	7	MCL	1.4
OW01-PZ03-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	7	RBC Tap	1.4
OW01-PZ03-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.05	MCL	200.0
OW01-PZ03-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.05	RBC Tap	200.0
OW01-PZ03-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-PZ03-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-PZ03-R01	BENZO(A)PYRENE	1.1	U	UG/L	1.1	0.2	MCL	5.5
OW01-PZ03-R01	BENZO(A)PYRENE	1.1	U	UG/L	1.1	0.2	RBC Tap	5.5
OW01-PZ03-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-PZ03-R01	TETRACHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	TETRACHLOROETHENE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-PZ03-R01	TRICHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	TRICHLOROETHENE	10	U	UG/L	10	5	RBC Tap	2.0
OW01-PZ03-R01	VINYL CHLORIDE	10	U	UG/L	10	2	MCL	5.0
OW01-PZ03-R01	VINYL CHLORIDE	10	U	UG/L	10	2	RBC Tap	5.0
OW01-PZ04-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-PZ04-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW01-PZ04-R01	BENZO(A)PYRENE	0.53	U	UG/L	0.53	0.2	MCL	2.7
OW01-PZ04-R01	BENZO(A)PYRENE	0.53	U	UG/L	0.53	0.2	RBC Tap	2.7

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW01-PZ05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-PZ05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-MW10-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW10-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-MW6-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW6-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-MW7D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW7D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-MW7-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW7-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-MW8D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW8D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-MW8D-R01	BENZO(A)PYRENE	0.5	U	UG/L	0.5	0.2	MCL	2.5
OW1-MW8D-R01	BENZO(A)PYRENE	0.5	U	UG/L	0.5	0.2	RBC Tap	2.5
OW1-MW8-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW8-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-PZ1-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-PZ1-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-PZ2P-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-PZ2P-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0
OW1-PZ2-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-PZ2-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	RBC Tap	20.0

Notes:

U = Non-detects at the detection limit

UL = Non-detected but biased low, the actual concentration is possibly higher

Appendix C
Supporting Statistics for Basewide Comparisons

Appendix C – Comparison of Site Concentrations to NAS Oceana-wide Concentrations

The relationship between site concentration and background, or nonsite-related, concentrations is an important consideration in the risk management process. Although no formal background study of inorganic chemicals has been completed at NAS Oceana (NASO), the considerable amount of data collected at all the sites at NASO can be used to determine whether inorganic concentrations at a particular site are different from those observed across the air station. The determination that the distribution of inorganic concentrations at a site is significantly different from the distribution of all other samples collected across the NASO would lead to a conclusion that the concentration pattern is unique, and possibly the result of a release (site-related). The evaluation was based upon the following principles:

1. The release histories at each site are different, involving different chemicals. The same chemicals were not released at each site.
2. Given that geological/physical conditions are generally comparable, chemicals that are naturally occurring should occur at every site in generally consistent concentrations.
3. Concentrations of non site-related chemicals should be consistent across sites where the was no direct release.

The 3 principles above lead to the following testable hypothesis:

The concentration distribution of an inorganic chemical at a site not resulting from a release will not be different from the concentration distribution of all other samples at NASO.

This hypothesis was tested for NASO sites using the parametric central tendency theorem and non-parametric Kruskal-Wallis test.

The null hypothesis for each parametric comparison becomes:

The site concentration is not significantly different than NASO-wide concentrations.

Acceptance of the null hypothesis would indicate that the concentrations at SWMUs 1 and/or 15 are similar to, or less than, those across NASO, suggesting there was no historical release at SWMUs 1 and/or 15. Rejection of the null hypothesis would indicate that the concentrations at SWMUs 1 and/or 15 are different than those across the NASO, suggesting there was a historical release.

The hypothesis was statistically tested for inorganic chemical concentrations at SWMUs 1 and 15. Data summaries (mean, standard deviation, sample sizes, and confidence intervals) of all surface soil, surface water, and sediment samples collected at SWMUs 1, 2B, 11, 15, 16, 16GC, 22, and 26 are presented in Table C-1. Table C-2 presents the confidence limits about the mean using the 95% confidence interval. The NASO-wide confidence limits were developed using all the data except the data from the site that is being tested.

According to the central tendency theory, when the site confidence limits overlap with the NASO-wide confidence limits, the null hypothesis is accepted. It can be concluded with 95% confidence that the two sets of data are not statistically different (i.e., they are from the same population) and that there is no evidence of site-relatedness.

The above testable hypothesis was also tested for NASO sites using the non-parametric Kruskal-Wallis test. The null hypothesis for each comparison was as follows:

Concentrations are not significantly different between NASO SWMUs.

Rejection of the null hypothesis would indicate that the concentrations at SWMUs 1 and/or 15 may be different than those across NASO, suggesting a potential historical release at SWMUs 1 and/or 15. The test, as applied, does not indicate which sites differ from each other. The test simply indicates whether there is a significant difference between the concentrations at one or more sites. Acceptance of the null hypothesis would indicate that the concentrations at SWMUs 1 and 15 are similar to those at other NASO SWMUs, suggesting there was no historical release at SWMUs 1 and 15.

Tables C-3 through C-5 present the results of the Kruskal-Wallis tests.

Table C-1
Summary Statistics
NAS Oceana, Virginia Beach, VA

SWMU 1					Basewide				
Chemical	**Mean**	**Standard Deviation**	**95% CI**	**Sample Size**	**Chemical**	**Mean**	**Standard Deviation**	**95% CI**	**Sample Size**
Surface Soil					**Surface Soil**				
Aluminum	12010	5712	6464	3	Aluminum	13654	3609	1716	17
Chromium	16	6.55	7.41	3	Chromium	64.7	185	88.0	17
Iron	8807	7523	8513	3	Iron	7045	5826	2770	17
Mercury	0.11	0.11	0.12	3	Mercury	0.09	0.14	0.07	17
Vanadium	16.7	5.46	6.18	3	Vanadium	20.2	6.46	3.07	17
Surface Water					**Surface Water**				
Aluminum	480	92.9	91.0	3	Aluminum	494	922	571	10
Iron	1283	37.7	37.0	3	Iron	553	673	417	10

SWMU 15					Basewide				
Chemical	**Mean**	**Standard Deviation**	**95% CI**	**Sample Size**	**Chemical**	**Mean**	**Standard Deviation**	**95% CI**	**Sample Size**
Surface Soil					**Surface Soil**				
Aluminum	12755	2430	2381	4	Aluminum	13570	4169	2043	16
Chromium	17.2	4.26	4.17	4	Chromium	67.5	191	93.5	16
Iron	6673	964	944	4	Iron	7469	6630	3249	16
Vanadium	18.1	3.36	3.29	4	Vanadium	20.0	6.89	3.38	16
Surface Water					**Surface Water**				
Aluminum	128	35.46	31.1	5	Aluminum	715	971	673	8
Sediment					**Sediment**				
Cyanide	0.31	0.34	0.17	16	Cyanide	0.06	0.06	0.04	6

95% CI = 95% Confidence Interval (see text)

Table C-2
Comparison Between Site and Air Station-wide 95 % Confidence Limits
NAS Oceana, Virginia Beach, VA

SWMU 1					Air Station-wide					
		95 % Confidence Limits					95 % Confidence Limits			Site Statistically Different than Air Station-wide?
Chemical	**Mean**	**Lower**	**-**	**Upper**	**Chemical**	**Mean**	**Lower**	**-**	**Upper**	
Surface Soil					**Surface Soil**					
Aluminum	12010	5546	-	18474	Aluminum	13654	11938	-	15369	No
Chromium	16.0	8.6	-	23.4	Chromium	64.7	0	-	153	No
Iron	8807	294	-	17320	Iron	7045	4276	-	9815	No
Mercury	0.11	0	-	0.23	Mercury	0.09	0.03	-	0.16	No
Vanadium	16.7	10.5	-	22.9	Vanadium	20.2	17.1	-	23.2	No
Surface Water					**Surface Water**					
Aluminum	480	389	-	571	Aluminum	494	0	-	1065	No
Iron	1283	1246	-	1320	Iron	553	135	-	970	**Yes**

SWMU 15					Air Station-wide					
		95 % Confidence Limits					95 % Confidence Limits			
Chemical	**Mean**	**Lower**	**-**	**Upper**	**Chemical**	**Mean**	**Lower**	**-**	**Upper**	
Surface Soil					**Surface Soil**					
Aluminum	12755	10374	-	15136	Aluminum	13570	11527	-	15613	No
Chromium	17.2	13.0	-	21.3	Chromium	67.5	0	-	161	No
Iron	6673	5728	-	7617	Iron	7469	4220	-	10718	No
Vanadium	18.1	14.8	-	21.4	Vanadium	20.0	16.6	-	23.4	No
Surface Water					**Surface Water**					
Aluminum	128	97.3	-	159	Aluminum	715	41.3	-	1388	No
Sediment					**Sediment**					
Cyanide	0.31	0.14	-	0.48	Cyanide	0.06	0.02	-	0.11	**Yes**

Although some confidence intervals may cause the lower confidence interval to fall to a negative number, these ranges are shown as starting at zero.

Table C-3
Analysis of Metals in Surface Soils at Oceana NAS
NAS Oceana, Virginia Beach, VA

Kruskal-Wallis ANOVA by Ranks

	Aluminum	Chromium	Iron	Mercury	Vanadium
H (6, N= 20) =	11.135	6.88	11.315	6.654	13.272
p-value*	0.08	0.33	0.08	0.35	**0.04**

*alpha level (0.05)

(p-value > 0.05 indicates no significant difference in the distributions of metal concentrations among SWMUs)

Table C-4
Analysis of Metals in Surface Water at Oceana NAS
NAS Oceana, Virginia Beach, VA

Kruskal-Wallis ANOVA by Ranks

	Aluminum	**Iron**
H (5, N=13) =	10.419	11.3
p-value*	0.064	**0.046**

*alpha level (0.05)

(p-value > 0.05 indicates no significant difference in the distributions of metal concentrations among SWMUs)

Table C-5
Analysis of Metals in Surface Soils at Oceana NAS
NAS Oceana, Virginia Beach, VA

Kruskal-Wallis ANOVA by Ranks	
	Cyanide
H (5, N= 25) =	14.833
p-value*	**0.01**

*alpha level (0.05)

(p-value > 0.05 indicates no significant difference in the distributions of metal concentrations among SWMUs)

Appendix D
Final Technical Memorandum for the Groundwater Sampling at SWMU 24

Final

Technical Memorandum for the Groundwater Sampling at SWMU 24

Oceana Naval Air Station
Virginia Beach, Virginia

CTO Task Order - 023
January 2000

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command

Under the

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Prepared by

CH2MHILL

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1.0 Introduction

This summary report documents the methods and results of groundwater sampling using both conventional and direct-push technology (DPT) at SWMU. The field work was conducted during late October and early November 1998.

At SWMU 24, subsurface groundwater samples were collected with a Geoprobe and analyzed using a close support laboratory (CSL). The study was conducted in the area of SWMU 24 where NoVOCs groundwater remediation was conducted in 1996. The purpose of the study was to support a decision whether to proceed with additional active groundwater remediation and if so, where to locate the treatment well(s) and monitoring system.

At SWMU 24, groundwater samples were also collected from monitoring wells and select piezometers to assess site-wide groundwater quality. The purpose of the standard low-flow groundwater sampling was to support a human health risk assessment.

This report is divided into two sections. The first section summarizes methods and results for the DPT groundwater sampling at SWMU 24. The second section of the report summarizes methods and results for the standard low-flow groundwater sampling at SWMU 24.

2.0 SWMU 24 Groundwater

The Navy implemented a 15-week pilot test of the NoVOCs™ in-well aeration groundwater treatment technology at SWMU 24 in 1996. Specific information pertaining to the pilot test including system design, pilot test monitoring, and system performance is contained in the *Final Report on the Pilot Test on the NoVOCs™ In-situ Aeration Technology at RCRA SWMU 24, Oceana Naval Air Station, Virginia Beach, Virginia* (CH2M HILL, April 1997). The analytical data for volatile organics suggest that the system was effective in substantially reducing the concentration of contaminants of concern *cis*-1,2-dichloroethene (*cis*-1,2-DCE) and trichloroethene (TCE) during the 15 weeks of pilot test operation, especially within a 40 foot radius of the treatment well. The mass reduction caused by the system also appears to be substantial. Estimates from mass balance calculations suggest that from 22 to 76 percent of the mass of *cis*-1,2-DCE was removed from the groundwater over the duration of the pilot test. The system functioned well after an initial period of field testing and adjustments, although a slightly decreasing flow rate suggests that minor clogging due to oxidized iron occurred during the test. The final report recommended the installation of additional treatment wells at SWMU 24. A work plan was developed and finalized (CH2M HILL, August 1998) to perform continued groundwater remediation at SWMU 24 using the NoVOCs™ technology. The objectives defined in the work plan for the additional groundwater remediation are (1) conduct a direct-push groundwater investigation on a sampling grid to evaluate where current plume boundaries are located, (2) install an additional NoVOCs™ treatment well and groundwater monitoring points, (3) remediate any areas of significant contamination, and (4) collect sufficient data to evaluate groundwater remediation success using the NoVOCs™ system.

2.1 Plume Delineation

CH2M HILL conducted a DPT groundwater investigation at SWMU 24 to define the location and character of the *cis*-1,2-DCE contaminant plume in order to support a decision regarding the need for additional groundwater remediation using NoVOCs™ in-well aeration technology.

The DPT groundwater samples were analyzed on site using a CSL. The CSL results are not validated and are considered to be useful as a screening level indicator of groundwater quality. Procedures and results of the DPT investigation are documented below.

Concurrently, groundwater samples were collected from the eleven shallow monitoring wells, one shallow piezometer, and one deep piezometer at SWMU 24 using standard low-flow groundwater sampling techniques. These groundwater samples were analyzed at an offsite for the full target compound list (TCL) organics and target analyte list (TAL) inorganics to support a human health risk assessment. Results of this sampling are documented in Section 3.

2.2 DPT Sampling Procedures

A total of one hundred thirteen groundwater samples were collected from forty locations distributed in a grid array. The DPT groundwater sampling locations are illustrated on Figure 2-1. At most locations a shallow (8 foot deep), an intermediate, (14 foot deep), and a deep (20 foot deep) filtered groundwater sample was extracted. The grid array was generated by sampling in four directions from the location of highest *cis*-1,2-DCE concentrations from previous sampling. The extent of groundwater contamination was defined as the location where the concentrations of detected parameters were no longer detected or were detected at concentrations below the MCLs or EPA Region III Risk Based Concentrations (RBCs) for tap water.

The DPT groundwater samples were analyzed in a CSL for modified Method 8010 chlorinated VOCs. The project was planned with the use of 8021 halogenated and chlorinated VOCs as the analytical method. However, the solicited subcontractors could not provide the close support laboratory equipment necessary to conduct the planned analyses within the proposed schedule of the project.

Ten chlorinated volatiles were included in the list of analytical parameters. They are 1,1-Dichloroethene, Methylene Chloride, *trans*-1,2-Dichloroethene, 1,1-Dichloroethane, *cis*-1,2-Dichloroethene, 1,1,1-Trichloroethane, Carbon Tetrachloride, Trichloroethene, 1,1,2-Trichloroethane, Tetrachloroethene.

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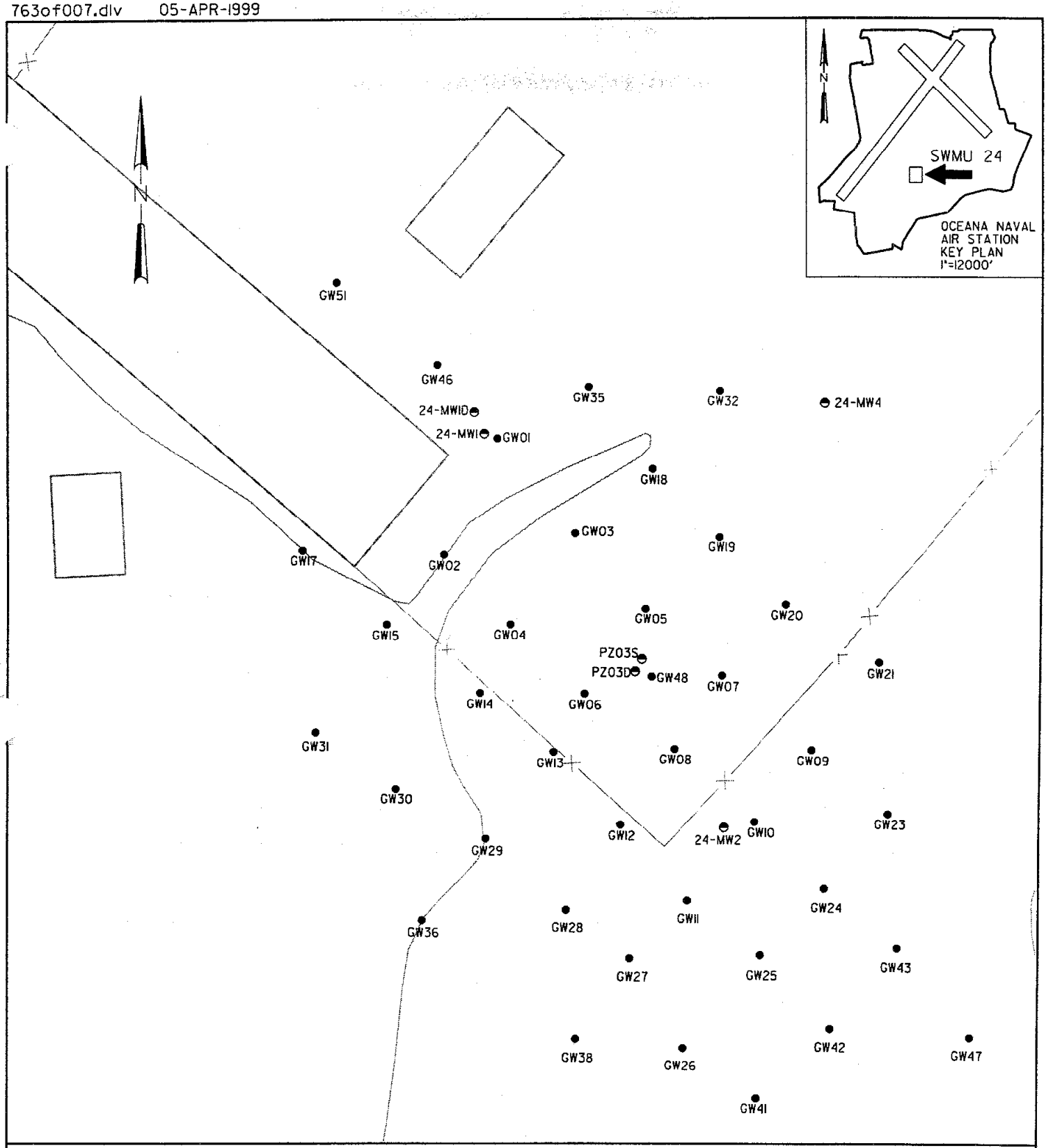

LEGEND

- ⊖ MONITORING WELL
- • DPT SAMPLING POINT

0 20 40 60
Scale in Feet

Figure 2-1
DPT AND MONITORING WELL I
GROUNDWATER SAMPLING LOCATIONS
AT SWMU 24
Naval Air Station, Oceana
Virginia Beach, Virginia

CH2MHILL

2.3 Results of the DPT Sampling

Detected contaminants in groundwater include *cis*-1,2-DCE, TCE, *trans*-1,2-dichloroethene (*trans*-1,2-DCE), benzene, ethylbenzene, and xylenes. The detected chemicals were compared to regulatory standards and criteria for groundwater to identify contaminants of concern. Those contaminants detected at concentrations that exceed federal maximum contaminant levels (MCLs) are *cis*-1,2-DCE, TCE, and benzene. The same contaminants also exceed the EPA Region III Risk Based Concentrations (RBCs) for tap water. Both *cis*-1,2-DCE and TCE were detected at several sample locations in the study area. Benzene was detected at only one sample location.

The DPT groundwater sampling results were plotted and contoured to illustrate the areal extent of the contaminant plumes and the vertical distribution of contaminant concentrations at depths of 8 and 14 feet below ground surface (bgs). Figure 2-2 depicts the areal distribution of *cis*-1,2-DCE concentrations at 8 feet bgs. Figure 2-3 depicts the areal distribution of *cis*-1,2-DCE concentrations at 14 feet bgs. Figure 2-4 depicts the areal distribution of trichloroethene concentrations at 14 feet bgs.

Table 2-1 summarizes the analytical detections at 8 feet bgs and Table 2-2 summarizes the analytical detections at 14 feet bgs. Appendix A-1 contains a summary of all analytical sample analyses, including detection limits. At a depth of 20 feet bgs there was only one detect (4.91 J of *cis*-1,2-DCE) at one sample location (location No.19). This detect is less than the MCL or the Region III Tap Water RBC. Therefore the 20-foot depth data are not plotted or contoured. TCE detections at 8 feet were not contoured because there were only three detects; all three were below the MCL and two of three were below the RBC.

At each DPT groundwater sampling location the detected concentrations of *cis*-1,2-DCE and TCE were averaged between the 8-foot, 14-foot, and 20-foot depths. When a contaminant was not detected one half of the detection limit was used. A contoured plot of the averaged *cis*-1,2-DCE concentrations is illustrated on Figure 2-5 and tabulated in Table 2-3. These derived data are more representative of the *cis*-1,2-DCE concentrations that would be detected using a standard shallow monitoring well at the same location because the DPT

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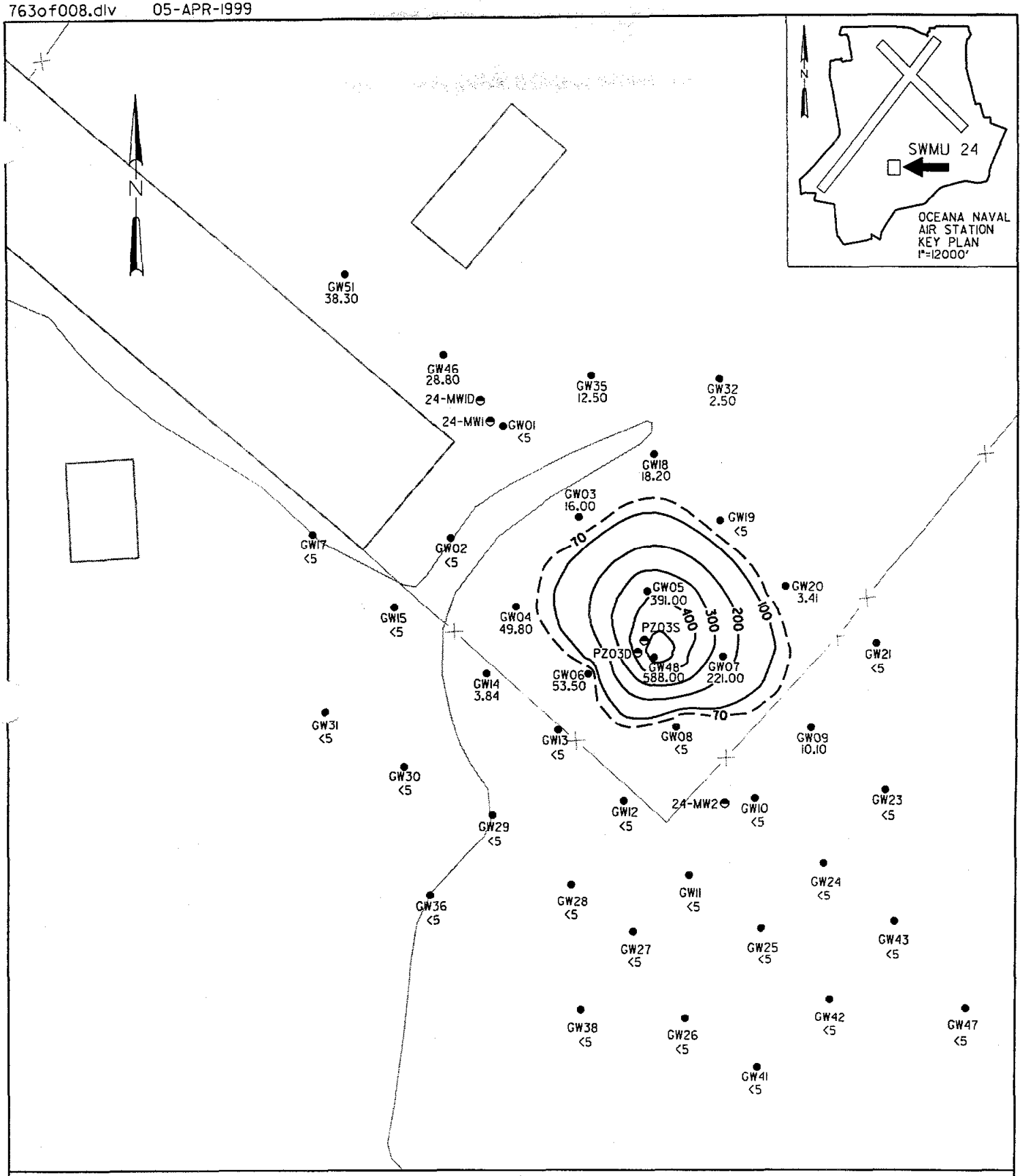

LEGEND

- MONITORING WELL
- DPT SAMPLING POINT
- – – MCL FOR 1,2-DCE (70 ug/l)

0 20 40 60
Scale In Feet

Figure 2-2
AREAL DISTRIBUTION OF CIS 1,2-DCE CONCENTRATIONS IN GROUNDWATER, 8 FEET BELOW GROUND SURFACE AT SWMU 24-NOVEMBER 1998
Naval Air Station, Oceana
Virginia Beach, Virginia

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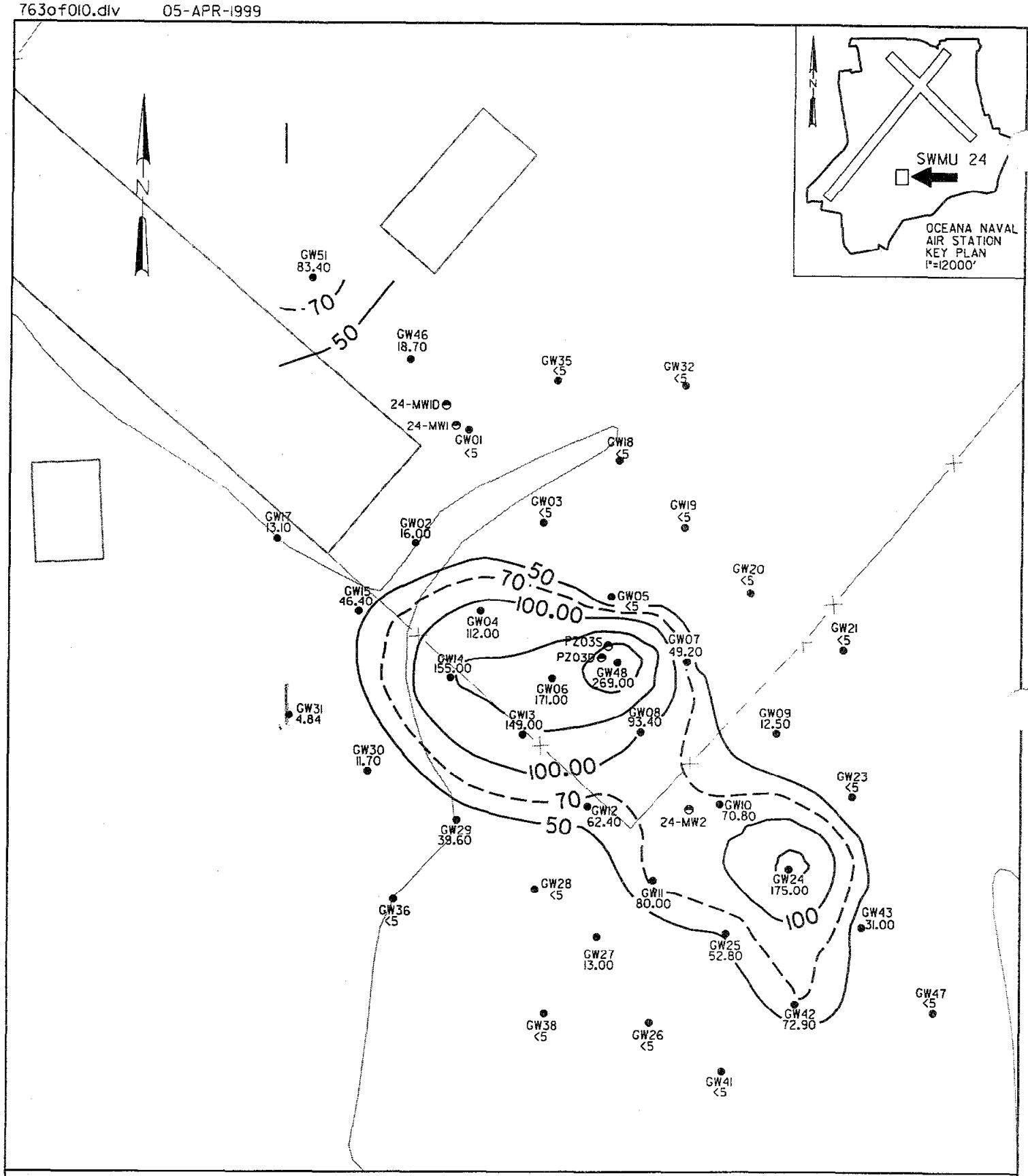

LEGEND

- MONITORING WELL
- DPT SAMPLING POINT
- MCL FOR 1,2-DCE (70 ug/l)

0 20 40 60
Scale In Feet

Figure 2-3
AREAL DISTRIBUTION OF CIS 1,2-DCE CONCENTRATIONS IN GROUNDWATER, 14 FEET BELOW GROUND SURFACE AT SWMU 24-NOVEMBER 1998

Naval Air Station, Oceana
Virginia Beach, Virginia

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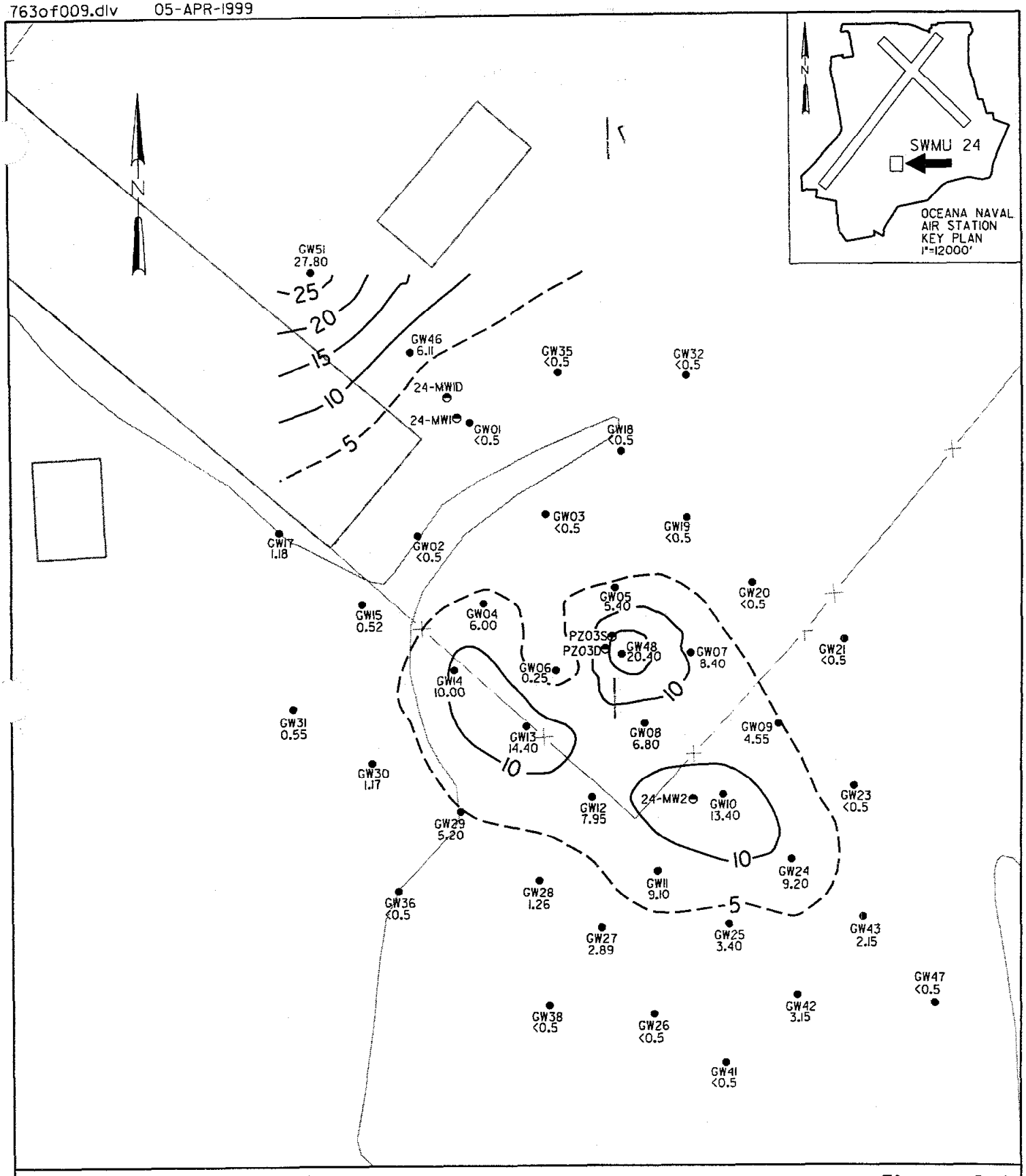

LEGEND

- ⊖ MONITORING WELL
- • DPT SAMPLING POINT
- — — MCL FOR TCE (5 ug/l)

0 20 40 60
Scale in Feet

Figure 2-4
AREAL DISTRIBUTION OF TCE CONCENTRATIONS IN GROUNDWATER AT 14 FEET BELOW GROUND SURFACE AT SWMU 24-NOVEMBER 1998

Naval Air Station, Oceana
Virginia Beach, Virginia

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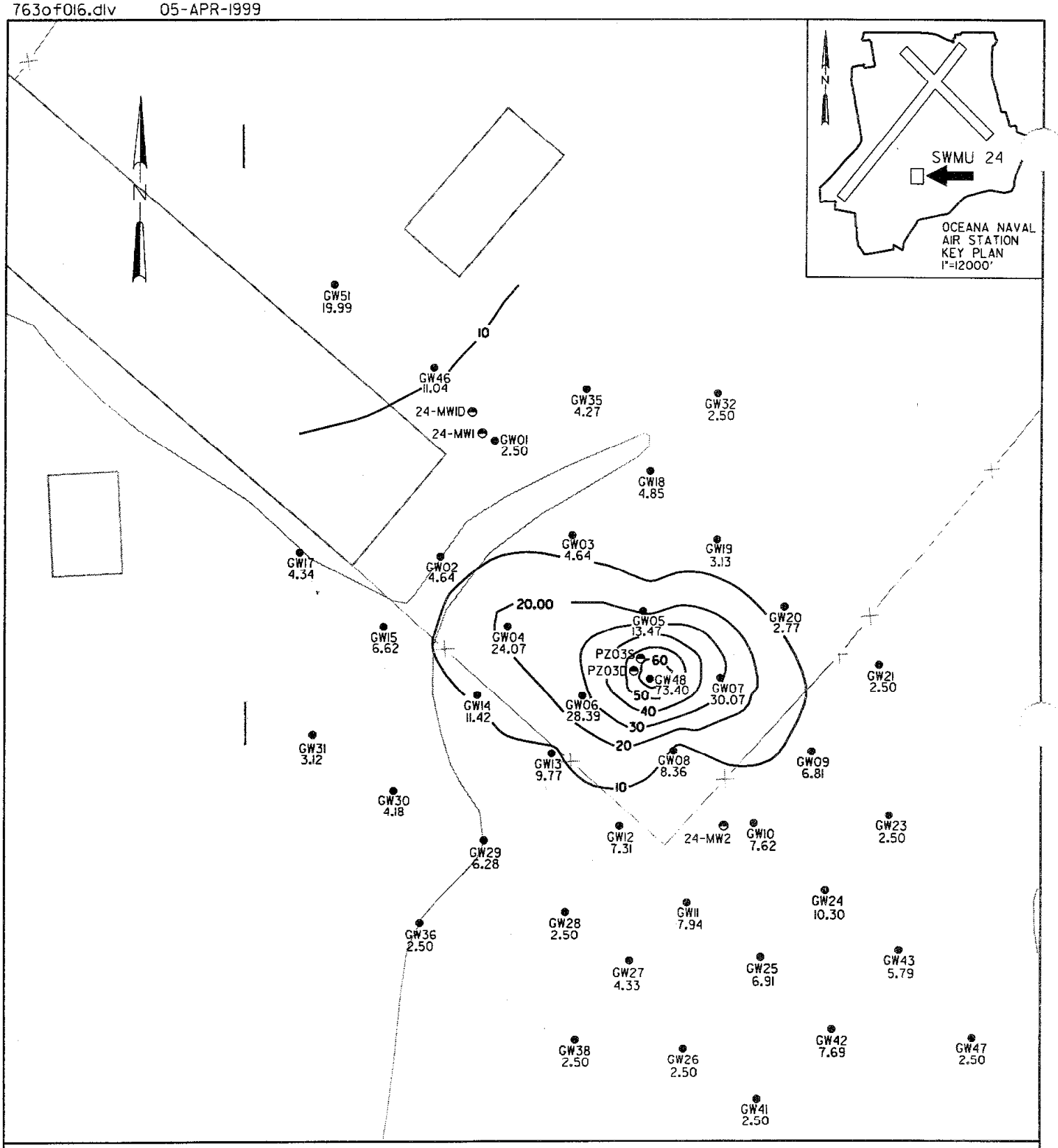

LEGEND

- MONITORING WELL
- DPT SAMPLING POINT

0 20 40 60
Scale in Feet

Figure 2-5
AVERAGED CIS-1,2-DCE CONCENTRATIONS IN GROUNDWATER FROM 8, 14 AND 20 FEET BELOW GROUND SURFACE, AT SWMU 24
NOVEMBER 1998
Naval Air Station, Oceana
Virginia Beach, Virginia

CH2MHILL

Table 2-1
Detected Chemicals in DPT Groundwater Samples from 8-feet Below Ground Surface, at SWMU 24
Naval Air Station, Oceana

Station ID	trans-1,2-DCE (µg/L)	cis-1,2-DCE (µg/L)	TCE (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	m&p-Xylenes (µg/L)	o-Xylenes (µg/L)
GW01	<5.0	<5.0	<0.5	<5.0	<5.0	ND	10.000	ND
GW02	<5.0	<5.0	<0.5	<5.0	<5.0	**89.1**	**17.0**	**6.45**
GW03	<5.0	**16.0**	<0.5	<5.0	<5.0	**6.47**	**9.850**	**20.3**
GW04	<5.0	**49.800**	<0.5	**6.28**	<5.0	**57.2**	**127**	**13.6**
GW05	<5.0	**391**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW06	**4.850**	**53.5**	**0.56**	<5.0	<5.0	<5.0	<5.0	<5.0
GW07	<5.0	**221.000**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW08	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW09	<5.0	**10.1**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW10	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW11	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW12	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW13	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW14	<5.0	**3.840**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW15	<5.0	<5.0	<0.5	<5.0	<5.0	**14.0**	**18.8**	<5.0
GW17	<5.0	<5.0	<0.5	<5.0	<5.0	**17.7**	**9.65**	<5.0
GW18	**3.510**	**18.2**	**2.530**	<5.0	<5.0	<5.0	<5.0	<5.0
GW19	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW20	<5.0	**3.4**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW21	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW23	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW24	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW25	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW26	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW27	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW28	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW29	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW30	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW31	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW32	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW35	<5.0	**12.5**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW36	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW38	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW41	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW42	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW43	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW46	<5.0	**28.8**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW47	<5.0	<5.0	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0
GW48	**44.70**	**588**	**1.18**	<5.0	<5.0	<5.0	<5.0	<5.0
GW51	<5.0	**38.3**	<0.5	<5.0	<5.0	<5.0	<5.0	<5.0

Table 2-2 Detected Chemicals in DPT Groundwater Samples from 14-feet BGS SWMU 24, Naval Air Station, Oceana			
Station ID	**trans-1,2-DCE (µg/L)**	**cis-1,2-DCE (µg/L)**	**TCE (µg/L)**
GW01	>5.0	>5.0	>0.5
GW02	>5.0	**16.0**	>0.5
GW03	>5.0	>5.0	>0.5
GW04	**13.0**	**112**	**6.00**
GW05	>5.0	>5.0	**5.40**
GW06	**12.8**	**171**	**0.25**
GW07	>5.0	**49.2**	**8.40**
GW08	**10.4**	**93.4**	**6.80**
GW09	>5.0	**12.5**	**4.55**
GW10	>5.0	**70.8**	**13.4**
GW11	**3.6**	**80.0**	**9.10**
GW12	>5.0	**62.4**	**7.95**
GW13	**9.50**	**149**	**14.4**
GW14	**9.80**	**155**	**10.0**
GW15	**3.4**	**46.4**	**0.52**
GW17	>5.0	**13.1**	**1.18**
GW18	>5.0	>5.0	>0.5
GW19	>5.0	>5.0	>0.5
GW20	>5.0	>5.0	>0.5
GW21	>5.0	>5.0	>0.5
GW23	>5.0	>5.0	>0.5
GW24	>5.0	**175.0**	**9.20**
GW25	>5.0	**52.8**	**3.40**
GW26	>5.0	>5.0	>0.5
GW27	>5.0	**13.0**	**2.89**
GW28	>5.0	>5.0	**1.26**
GW29	>5.0	**39.6**	**5.20**
GW30	>5.0	**11.7**	**1.17**
GW31	>5.0	**4.8**	**0.55**
GW32	>5.0	>5.0	>0.5
GW35	>5.0	>5.0	>0.5
GW36	>5.0	>5.0	>0.5
GW38	>5.0	>5.0	>0.5
GW41	>5.0	>5.0	>0.5
GW42	>5.0	**72.9**	**3.15**
GW43	>5.0	**31.0**	**2.15**
GW46	>5.0	**18.7**	**6.11**
GW47	>5.0	>5.0	>0.5
GW48	**19.1**	**269**	**20.4**
GW51	>5.0	**83.4**	**27.8**

Table 2-3 Averaged Concentrations of cis1,2-DCE and TCE from 8, 14, and 20 Feet Deep SWMU 24, Naval Air Station, Oceana		
Sample Location	**cis-1,2-DCE (µg/L)**	**TCE (µg/L)**
GW01	2.50	0.25
GW02	4.64	0.25
GW03	4.64	0.25
GW04	24.07	0.72
GW05	13.47	0.70
GW06	28.39	0.33
GW07	30.07	0.81
GW08	8.36	0.75
GW09	6.81	0.66
GW10	7.62	0.94
GW11	7.94	0.83
GW12	7.31	0.79
GW13	9.77	0.97
GW14	11.42	0.85
GW15	6.62	0.32
GW17	4.34	0.42
GW18	4.85	0.54
GW19	3.13	0.25
GW20	2.77	0.25
GW21	2.50	0.25
GW23	2.50	0.25
GW24	10.30	0.83
GW25	6.91	0.60
GW26	2.50	0.25
GW27	4.33	0.57
GW28	2.50	0.43
GW29	6.28	0.69
GW30	4.18	0.42
GW31	3.12	0.33
GW32	2.50	0.25
GW35	4.27	0.25
GW36	2.50	0.25
GW38	2.50	0.25
GW41	2.50	0.25
GW42	7.69	0.58
GW43	5.79	0.51
GW46	11.04	0.73
GW47	2.50	0.25
GW48	73.40	1.82
GW51	19.99	1.20

utilizes a 1-foot sampling interval whereas a standard monitoring well utilizes a several-foot monitoring interval. Figure 2-5 shows that the MCL for the averaged *cis*-1,2-DCE concentrations is exceeded only at one location, that of GW-48.

A groundwater sample was collected from piezometers PZ3S (screened from 6 to 14 feet bgs) and PZ3D (screened from 20-25 feet). DPT sample location GW-48 is located adjacent to these piezometers. A groundwater sample was collected from monitoring well MW01 (screened from 5 to 20 feet). DPT sample location GW-01 is adjacent to this well. A groundwater sample was collected from monitoring well MW02 (screened from 5 to 20 feet). DPT sample location GW-10 is adjacent to this well. The groundwater samples from these wells/piezometers were split and analyzed in both the CSL and an offsite laboratory. The split sample results from the above-noted monitoring wells (from both the offsite laboratory and the CSL) and the averaged CSL analytical results from three depths from the adjacent DPT sample locations are tabulated in Table 2-4. Boldface values indicate detects and non-boldface values are the detection limits. DPT results are from depths of 8, 14, and 20 feet bgs and were averaged using a geometric mean. One half of the detection limit was used for non-detects. The comparison of these data shows some variability between results. However the data support an interpretation of the presence of a localized *cis*-1,2-DCE hot spot near PZ3 and GW-48 that has a limited areal and vertical extent.

2.3.1 Water Table Elevations

Depth to groundwater measurements were completed in site monitoring wells during the DPT investigation. A water table contour map of the DPT site investigation area was made from these measurements and is illustrated in Figure 2-6. The groundwater flow is generally south-southeasterly. This groundwater flow direction is congruent with the location of the remnants of the original *cis*1,2-DCE groundwater contaminant plume that originated near 24-MW1 and was characterized during the DPT investigation.

Table 2-4
Comparison of Laboratory, CSL, and Averaged DPT Groundwater Parameter Concentrations at Similar Locations
SWMU 24, NAS Oceana

Sample Location	PZ3S LAB	PZ3S CSL	PZ3D LAB	PZ3D CSL	DPT - GW48 CSL Averaged Concentration	MW01 Lab	MW01 CSL	DPT - GW01 CSL Averaged Concentration	MW02 Lab	MW02 CSL	DPT - GW10 CSL Averaged Concentration
Parameter	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
1,1-Dichloroethene	1	**7.77**	1	**7**	2.5	1	5	2.5	1	5	2.5
Methylene Chloride	**0.6**	5	**0.5 B**	5	2.5	1	5	2.5	1	5	2.5
trans-1,2-Dichloroethene	**65 J**	**3.41 J**	**4.5**	**47.3**	**12.88**	**8.8**	**3.48**	2.5	1	5	2.5
1,1-Dichloroethane	1	5	1	5	2.5	1	5	2.5	1	5	2.5
cis-1,2-Dichloroethene	**500**	**29.8 E**	**39.1**	**339**	**73.4**	**59.8**	**48.9**	2.5	**0.2 J**	5	**7.62**
1,1,1-Trichloroethane	1	0.5	1	0.5	0.25	1	0.5	0.25	1	0.5	0.25
Carbon Tetrachloride	1	0.5	1	0.5	0.25	1	0.5	0.25	1	0.5	0.25
Trichloroethene	**0.6 J**	**1.68**	**1.9**	**0.06**	**1.82**	1	0.5	0.25	1	0.5	**0.94**
1,1,2-Trichloroethane	1	0.5	1	0.5	0.25	1	0.5	0.25	1	0.5	0.25
Tetrachloroethene	1	0.5	1	0.5	0.25	1	0.5	0.25	1	0.5	0.25
Vinyl Chloride	**2.5**	NA	1	NA	NA	1	NA	NA	1	NA	NA

Notes:

DPT results are from depths of 8, 14, and 20 feet bgs and were averaged using a geometric mean. One half of the detection limit was used for non-detects.

J = estimated value

B = detected in blank

E = exceed calibration range

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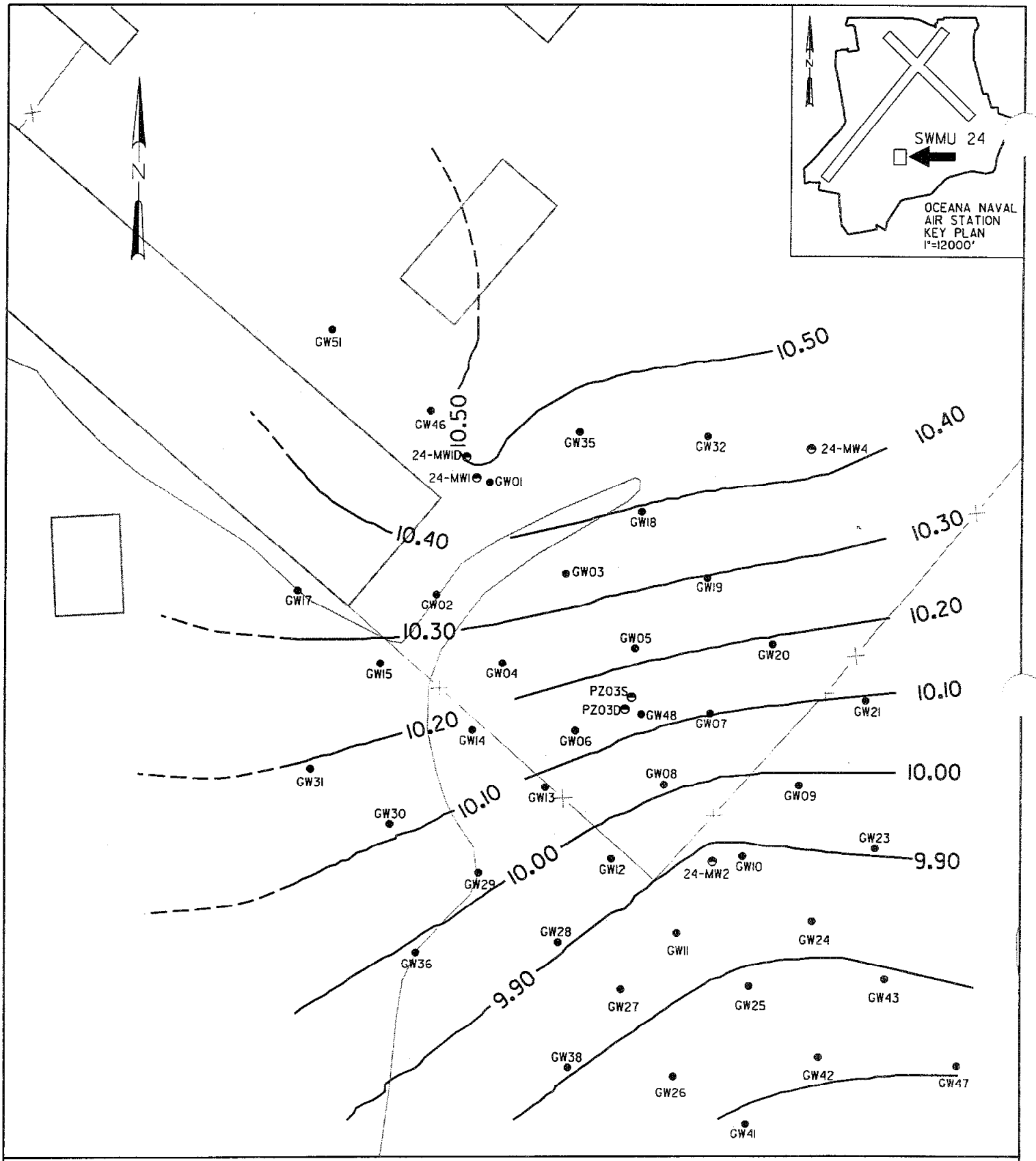


LEGEND

- MONITORING WELL
- SAMPLING POINT
- WATER TABLE ELEVATION CONTOUR

0 20 40 60
Scale In Feet

Figure 2-6
WATER TABLE ELEVATION MAP
OF DPT INVESTIGATION AREA
AT SWMU 24-NOVEMBER 1998

Naval Air Station, Oceana
Virginia Beach, Virginia

CH2MHILL

3.0 SWMU 24 Groundwater Sampling

Groundwater sampling activities at SWMU-24 were conducted by CH2M HILL, Inc., from October 27 through November 6, 1998, to support risk assessment as requested by the USEPA in October 1998. Prior to this sampling event, groundwater at SWMU-24 had been sampled as part of the Corrective Measure Study conducted in 1993 and 1994.

3.1 Groundwater Sampling Procedures for Monitoring Wells and Piezometers

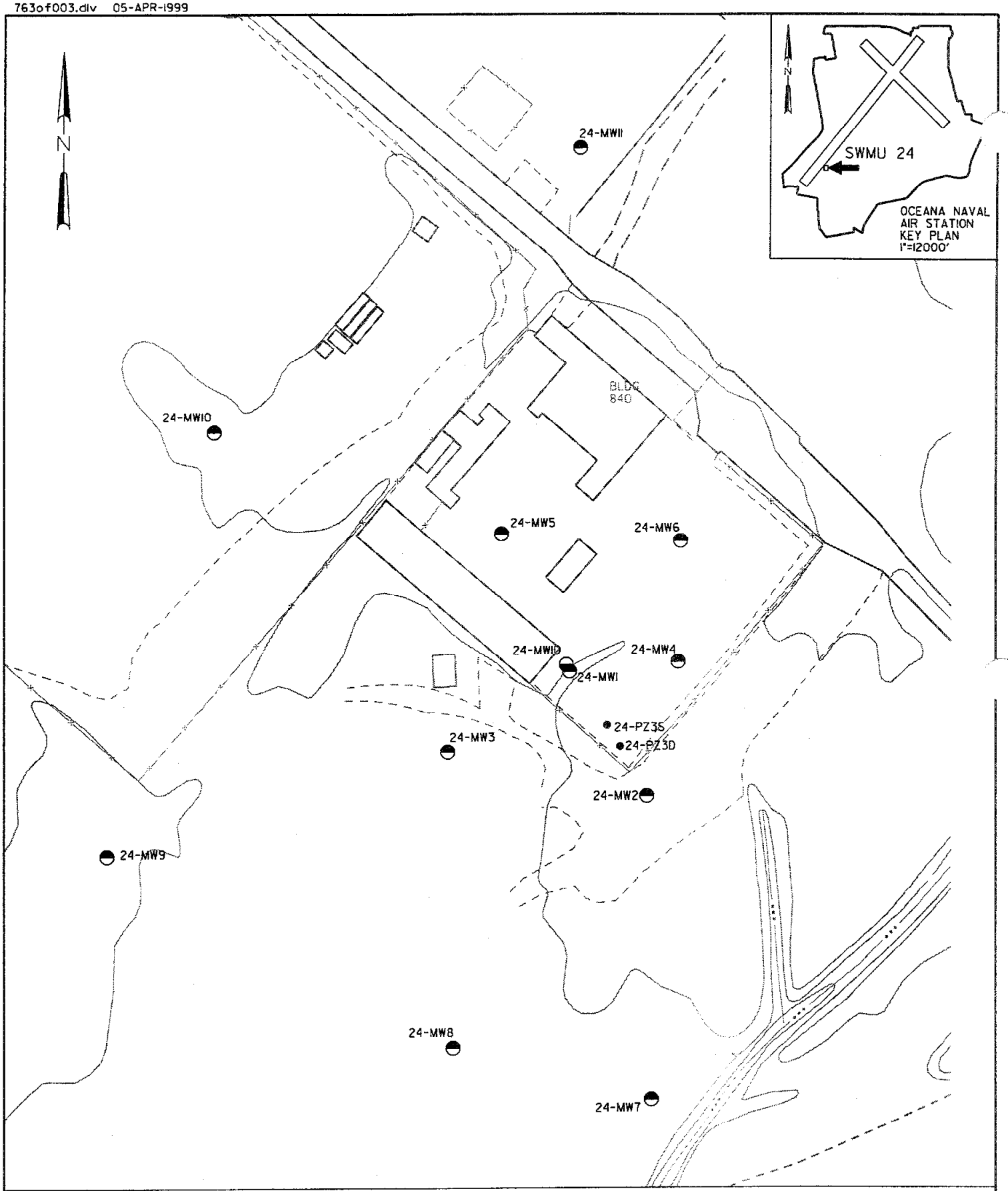
From October 27 through November 6, 1998, groundwater samples were collected from twelve monitoring wells (MW01, MW1D, MW02, MW03, MW04, MW05, MW06, MW07, MW08, MW09 MW10 and MW11), one shallow piezometer (PZ3S), and one deep piezometer (PZ3D), at SWMU-24. These groundwater sampling locations are illustrated in Figure 3-1.

All groundwater samples were collected using a low-flow Grundfos pump with dedicated tubing in accordance with CH2M HILL, Inc.'s standard operating procedures (SOPs) for groundwater sampling.

Upon collection, all groundwater samples were submitted to an offsite laboratory (GP Environmental of Gaithersburg, MD) for analysis of Target Compound List (TCL) Low-concentration (LC) Volatile Organic Compounds (VOCs), TCL Semi-Volatile Organic Compounds (SVOCs), TCL Pesticides and PCBs, Polyaromatic Hydrocarbons (PAHs) by EPA Method 8310, Target Analyte List (TAL) Dissolved Metals and Cyanide, and TAL Total Metals and Cyanide. These analyses were chosen to support a human health risk assessment of this site.

Water levels were measured prior to groundwater sampling and are presented in Table 3-1 below. A water table map was produced from these measurements (Figure 3-2). The water table map illustrates general groundwater flow directions which varies from southeasterly to southwesterly across the site.

763of003.dlv 05-APR-1999



LEGEND

- SHALLOW MONITORING WELL
- DEEP MONITORING WELL

0 60 120 180

SCALE IN FEET

Figure 3-1
GROUNDWATER SAMPLING LOCATIONS AT SWMU 24
Naval Air Station, Oceana
Virginia Beach, Virginia

CH2MHILL

Table 3-1
SWMU-24 Groundwater Elevations
October 27-November 6, 1998

Location	Top of PVC Elevation (ft)	Depth To Groundwater from Top of PVC (feet)	Elevation of Groundwater Surface (feet)
OW24-MW01-R01	17.34	6.87	10.47
OW24-MW1D-R01	17.33	6.82	10.51
OW24-MW02-R01	18.76	8.88	9.88
OW24-MW03-R01	16.06	5.80	10.26
OW24-MW04-R01	17.37	6.94	10.43
OW24-MW05-R01	17.14	6.81	10.33
OW24-MW06-R01	17.79	7.16	10.63
OW24-MW07-R01	15.77	6.70	9.07
OW24-MW08-R01	17.02	7.16	9.86
OW24-MW09-R01	16.44	6.49	9.95
OW24-MW10-R01	16.32	5.88	10.44
OW24-MW11-R01	16.7	5.65	11.05
OW24-PZ3D-R01	NA	6.72	NA
OW24-PZ3S-R01	NA	6.41	NA

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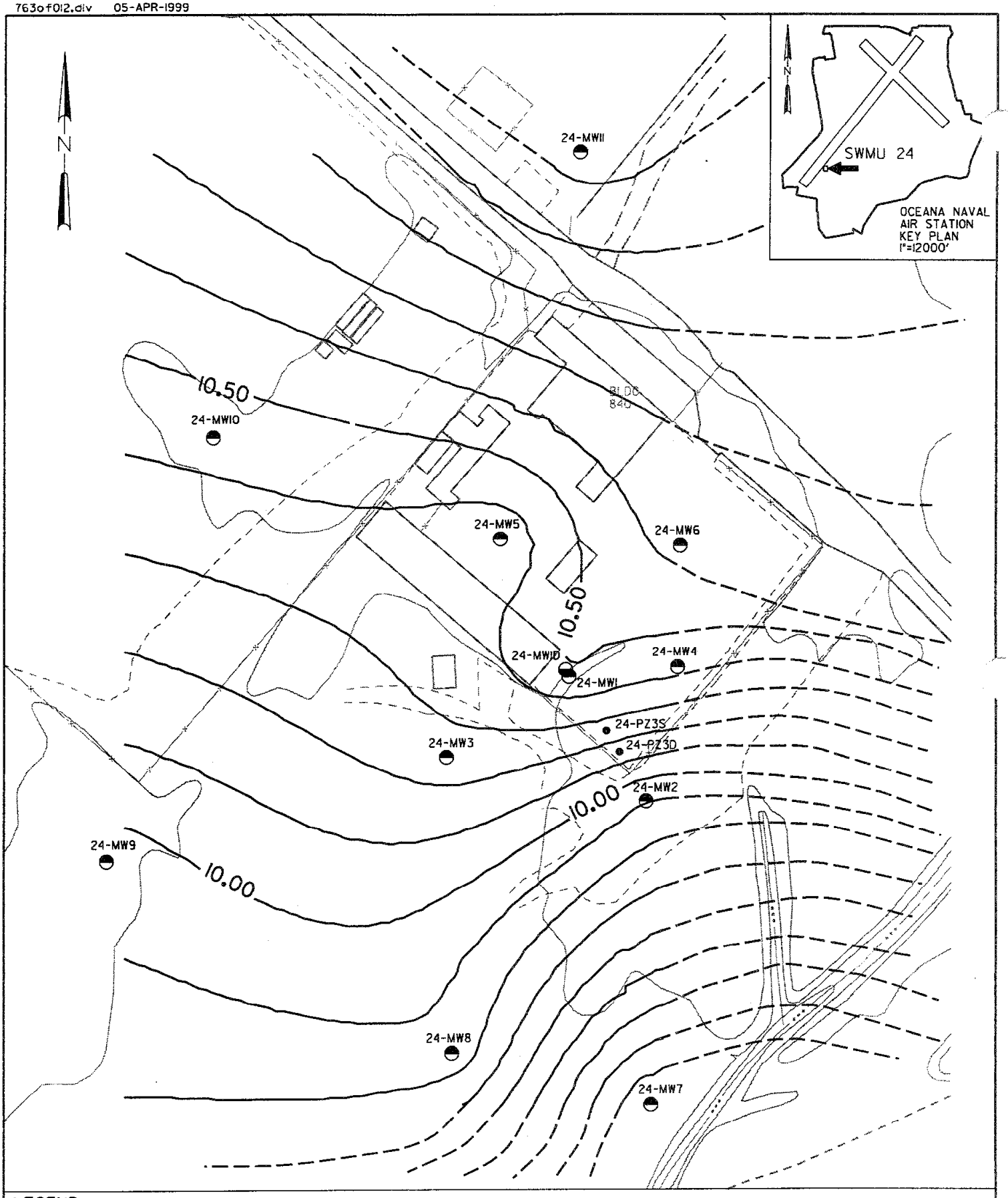

LEGEND

- SHALLOW MONITORING WELL
- DEEP MONITORING WELL
- WATER TABLE ELEVATION CONTOUR

0 60 120 180

SCALE IN FEET

Figure 3-2
WATER TABLE ELEVATION MAP
FOR SWMU 24-NOVEMBER 1998

Naval Air Station, Oceana
Virginia Beach, Virginia

CH2MHILL

3.2 SWMU-24 Groundwater Sampling Results

Sampling results for the October-November 1998 groundwater sampling activities at SWMU-24 are documented below. The detected chemicals from the validated analytical groundwater data are located in Appendix A-2.

Fourteen groundwater samples were analyzed for TCL LC-VOCs, TCL SVOCs, TCL Pesticides and PCBs, PAHs by EPA Method 8310, TAL Dissolved Metals and Cyanide, and TAL Total Metals and Cyanide.

CH2M HILL compared the groundwater analytical results to the EPA Region III RBC screening levels for tap water and EPA MCLs for drinking water. Figure 3-3 illustrates the locations where the detected chemical concentrations exceeded screening levels or regulatory standards. Where a chemical concentration exceeded more than one screening level or regulatory standard, both exceedances were posted and labeled. Table 3-2 lists the location of the exceeding concentrations, sample collection dates, chemicals that exceeded screening limits, the analytical results, any data validation qualifiers, the detection limits, the screening levels or regulatory standards, and the exceedance quotients. The exceedance quotient is the detected concentration divided by the regulatory limit. It serves as a quick assessment of the degree to which specific chemicals exceed regulatory limits. Where a chemical exceeded more than one screening level or regulatory standard, both were tabulated.

Chemicals with non-detect values but have detection limits that exceeded regulatory screening limits for EPA Region III RBC screening levels for tap water or EPA MCLs for drinking water are tabulated in Appendix A-3.

In summary, various analytes exceeded groundwater regulatory criteria at SWMU-24 as listed below:

- Arsenic concentrations exceeded the Region III RBC for tap water in the following samples MW01 (filtered and unfiltered samples), MW02 (filtered and unfiltered samples), MW03 (unfiltered), MW04 (filtered and unfiltered samples), MW7 (filtered and unfiltered samples), MW8 (unfiltered), MW10 (filtered and unfiltered sample),

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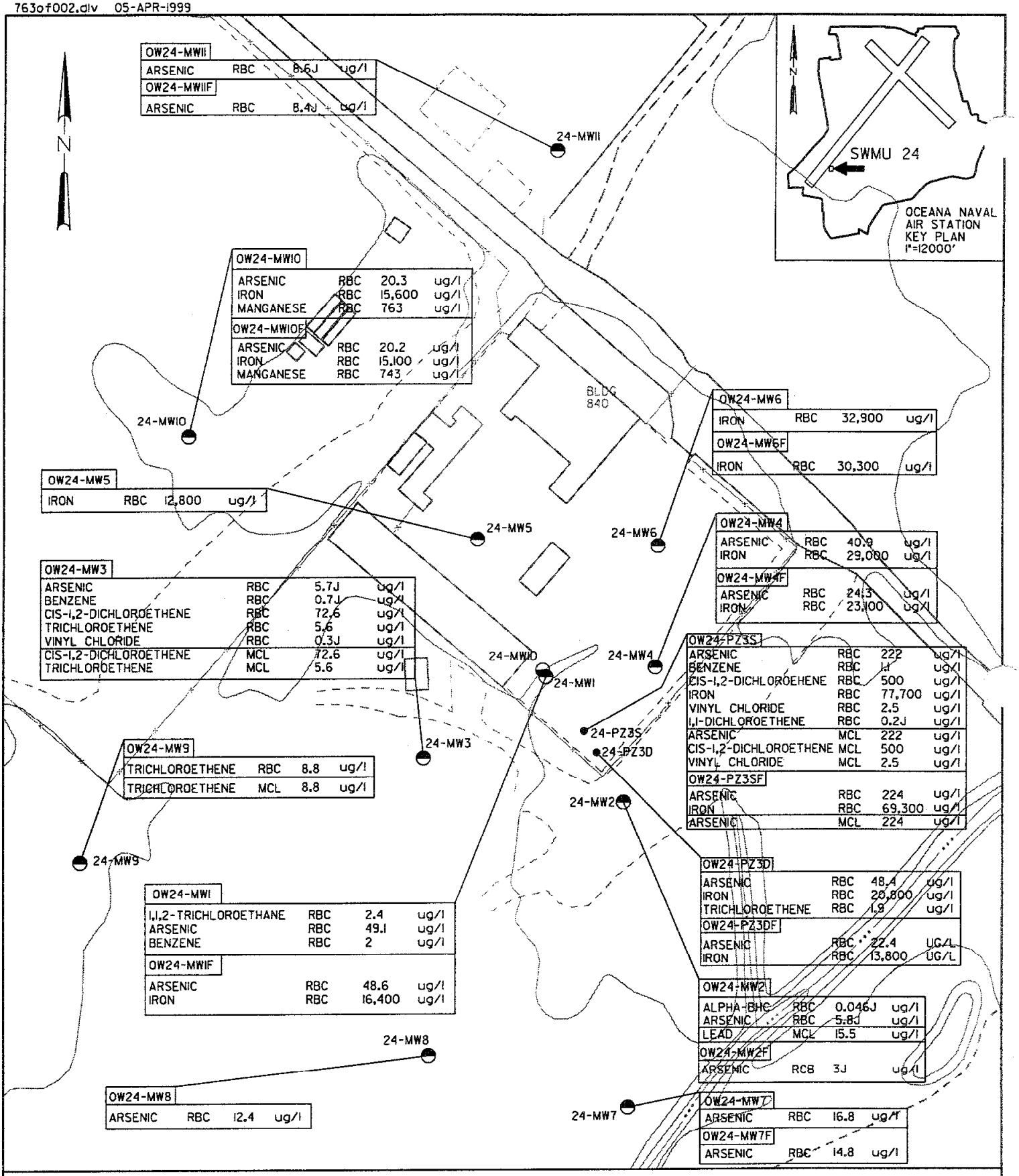

LEGEND

- SHALLOW MONITORING WELL
- DEEP MONITORING WELL

0 60 120 180
SCALE IN FEET

Figure 3-3
CHEMICALS DETECTED IN GROUNDWATER THAT EXCEED REGION III RCB SCREENING LEVELS FOR TAP WATER OR EPA MCLs FOR DRINKING WATER AT SWMU 24- NOVEMBER 1998
Naval Air Station, Oceana
Virginia Beach, Virginia

CH2MHILL

Table 3-2
Groundwater Exceedances of Regulatory Criteria Values
SWMU-24, Oceana Naval Air Station, Virginia Beach, Virginia

Sample ID	Date Sample Collected	Analyte	Analytical Value (ug/L)	Data Validation Qualifier	Detection Limit (ug/L)	Regulatory Criteria	Regulatory Criteria Value	Exceedance Quotient[1]
OW24-MW01-R01	10/27/1998	1,1,2-Trichloroethane	2.4		1	RBC Tap	0.19	12.6
OW24-MW01-R01	10/27/1998	Arsenic	49.1		3	RBC Tap	0.045	1091.1
OW24-MW01-R01	10/27/1998	Benzene	2		1	RBC Tap	0.36	5.6
OW24-MW01-R01	10/27/1998	Iron	17700		23.5	RBC Tap	11000	1.6
OW24-MW01F-R01	10/27/1998	Arsenic	48.6		3	RBC Tap	0.045	1080.0
OW24-MW01F-R01	10/27/1998	Iron	16400		23.5	RBC Tap	11000	1.5
OW24-MW02-R01	10/30/1998	Alpha-BHC	0.046	J	0.1	RBC Tap	0.011	4.2
		Arsenic	4.8	J	3	RBC Tap	0.045	106.7
		Lead	15.5		1.7	MCL	15	1.0
OW24-MW02PF-R01	10/30/1998	Arsenic	3	J	3	RBC Tap	0.045	66.7
OW24-MW02P-R01	10/30/1998	Arsenic	5.8	J	3	RBC Tap	0.045	128.9
OW24-MW03-R01	11/04/1998	Arsenic	5.7	J	3	RBC Tap	0.045	126.7
		Benzene	0.7	J	1	RBC Tap	0.36	1.9
		Cis-1,2-Dichloroethene	72.6		5	RBC Tap	61	1.2
						MCL	70	1.0
		Trichloroethene	5.6		1	RBC Tap	1.6	3.5
						MCL	5	1.1
		Vinyl Chloride	0.3	J	1	RBC Tap	0.019	15.8
OW24-MW04-R01	10/28/1998	Arsenic	40.9		3	RBC Tap	0.045	908.9
		Iron	29000		23.5	RBC Tap	11000	2.6
OW24-MW04F-R01	10/28/1998	Arsenic	24.3		3	RBC Tap	0.045	540.0
		Iron	23100		23.5	RBC Tap	11000	2.1
OW24-MW05-R01	10/27/1998	Iron	12800		23.5	RBC Tap	11000	1.2
OW24-MW06-R01	10/27/1998	Iron	32900		23.5	RBC Tap	11000	3.0
OW24-MW06F-R01	10/27/1998	Iron	30300		23.5	RBC Tap	11000	2.8
OW24-MW7-R01	11/06/1998	Arsenic	16.8		3	RBC Tap	0.045	373.3
OW24-MW7F-R01	11/06/1998	Arsenic	14.8		3	RBC Tap	0.045	328.9
OW24-MW8-R01	11/06/1998	Arsenic	12.4		3	RBC Tap	0.045	275.6
OW24-MW9-R01	11/06/1998	Trichloroethene	8.8		1	RBC Tap	1.6	5.5
						MCL	5	1.8
OW24-MW10-R01	11/06/1998	Arsenic	20.3		3	RBC Tap	0.045	451.1
		Iron	15600		23.5	RBC Tap	11000	1.4
		Manganese	763		1.1	RBC Tap	730	1.0
OW24-MW10F-R01	11/06/1998	Arsenic	20.2		3	RBC Tap	0.045	448.9
		Iron	15100		23.5	RBC Tap	11000	1.4
		Manganese	743		1.1	RBC Tap	730	1.0
OW24-MW11-R01	11/04/1998	Arsenic	8.1	J	3	RBC Tap	0.045	180.0
OW24-MW11F-R01	11/04/1998	Arsenic	4.8	J	3	RBC Tap	0.045	106.7
OW24-MW11PF-R01	11/04/1998	Arsenic	8.4	J	3	RBC Tap	0.045	186.7
OW24-MW11P-R01	11/04/1998	Arsenic	8.6	J	3	RBC Tap	0.045	191.1
OW24-PZ3D-R01	11/04/1998	Iron	20800		23.5	RBC Tap	11000	1.9
		Trichloroethene	1.9		1	RBC Tap	1.6	1.2
		Arsenic	48.4		3	RBC Tap	0.045	1075.6
OW24-PZ3DF-R01	11/04/1998	Arsenic	22.4		3	RBC Tap	0.045	497.8
		Iron	13800		23.5	RBC Tap	11000	1.3
OW24-PZ3S-R01	11/04/1998	1,1-Dichloroethene	0.2	J	1	RBC Tap	0.044	4.5
		Arsenic	222		3	RBC Tap	0.045	4933.3
						MCL	50	4.4
		Benzene	1.1		1	RBC Tap	0.36	3.1
		Cis-1,2-Dichloroethene	500		100	RBC Tap	61	8.2
						MCL	70	7.1
		Iron	77700		23.5	RBC Tap	11000	7.1
		Vinyl Chloride	2.5		1	RBC Tap	0.019	131.6
						MCL	2	1.3
OW24-PZ3SF-R01	11/04/1998	Arsenic	224		3	RBC Tap	0.045	4977.8
						MCL	50	4.5
		Iron	69300		23.5	RBC Tap	11000	6.3

Notes:
J - Estimated
F - Filtered Sample
P - Duplicate Sample
RBC Tap Water - EPA Region III Risk-Based Concentration for tap water
MCL - EPA Maximum Concentration Limit for drinking water
[1]Exceedance Quotient is calculated as follows: Analytical Value/Regulatory Criteria Value

MW11 (filtered and unfiltered samples), PZ3D (filtered and unfiltered samples) and PZ3S (filtered and unfiltered samples); and exceeded the EPA MCL for drinking water in sample PZ3S (filtered and unfiltered samples).

- Iron concentrations exceeded the Region III RBC for tap water in samples MW01 (filtered and unfiltered samples), MW04 (filtered and unfiltered samples), MW05, MW06 (filtered and unfiltered samples), MW10 (filtered and unfiltered samples), PZ3D (filtered and unfiltered samples) and PZ3S (filtered and unfiltered samples).
- The lead concentration exceeded the EPA MCL for drinking water in sample MW02.
- The manganese concentrations exceeded the Region III RBC for tap water in samples MW10 (filtered and unfiltered samples).
- The 1,1,2-trichloroethane concentration exceeded the Region III RBC for tap water in sample MW01.
- The benzene concentrations exceeded the Region III RBC for tap water in samples MW01, MW03, and PZ3S.
- The Alpha-BHC concentration exceeded the Region III RBC for tap water in sample MW02.
- The cis-1,2-dichloroethene concentrations exceeded the Region III RBC for tap water and EPA MCL for drinking water in samples MW03 and PZ3S.
- The trichloroethene concentrations exceeded the Region III RBC for tap water in samples MW03, MW9 and PZ3D, and exceeded the EPA MCL for drinking water in samples MW03 and MW9.
- The 1,1-dichloroethene concentration exceeded the Region III RBC for tap water in sample PZ3S.
- The vinyl chloride concentrations exceeded the Region III RBC for tap water in samples MW03 and PZ3S, and exceeded the EPA MCL for drinking water in sample PZ3S.

4.0 Conclusions and Recommendations

This section documents conclusions and recommendations for the SWMU 24 DPT groundwater study and the SWMU-wide monitoring well groundwater sampling.

4.1 Conclusions

The encouraging results of the single-well pilot test of the suggest that the NoVOCs™ technology is particularly suitable for hot-spot remediation of relatively small areas, and may be suitable for wider application at the Oceana Naval Air Station and at other contaminated sites.

Results of the SWMU 24 DPT groundwater study in and around the former NoVOCs groundwater remediation area indicate that the groundwater contains chlorinated VOCs, specifically cis1,2-DCE and TCE, at concentrations that exceed MCLs and RBCs for tap water. The residual groundwater contamination exists hydraulically downgradient of the NoVOCs™ treatment well. The highest contaminant concentrations are detected at a depth of approximately 14 feet below ground surface. The Navy has determined that the installation of a second NoVOCs™ well at SWMU 24 is not economically feasible due to the limited areal and vertical extent of cis1,2-DCE in groundwater at concentrations exceeding the MCL.

The Navy has found that the groundwater underlying the remainder of SWMU 24 contains chlorinated VOCs, specifically cis1,2-DCE, TCE, and vinyl chloride, at concentrations that exceed MCLs and RBCs for tap water. Arsenic and iron also exceed the RBC. However, the concentrations of these chemicals do not warrant active groundwater remediation.

4.2 Recommendations

The Navy and EPA plan to develop a monitored natural attenuation (MNA) plan for NAS Oceana for other sites on the activity. The general MNA plan will establish the overall MNA protocol, and individual sections of the plan will define the specific details to

implement MNA at individual sites proposed for MNA. The Navy proposes to consider SWMU 24 for inclusion in the NAS Oceana MNA plan. In addition, the Navy proposes to investigate the feasibility of localized groundwater remediation, near the PZ3 piezometer pair (shown in Figure 2-5) by injection of an oxygen-releasing-compound (ORC) or a hydrogen-releasing-compound (HRC).

4.2.1 Future Plans

The Navy will prepare human health risk assessment assumptions for this SWMU to facilitate the assessment of site-wide groundwater sampling results. These assumptions will be forwarded to the EPA program toxicologist for approval. Prior to proceeding with the risk assessment the Navy proposes to meet with the EPA and VDEQ to determine what additional data might be required in order to complete the risk assessment. The Navy will also provide a conceptual ecological model of SWMU 24 that includes physiography and proposed future land use surrounding the site. The model will be used to evaluate any potential pathways for ecological receptors and to support a management decision pertaining to ecological risks at the SWMU.

The Navy will conduct a human health risk assessment. Upon completion of the risk assessment the Navy will proceed with a Focused Feasibility Study (FFS) for the SWMU. Once a remedial alternative is selected in the FFS the Navy will prepare a Proposed Remedial Action Plan (PRAP) and a record of decision (ROD).

Appendix A-1

CSL Analytical Results of the DPT Investigation of SWMU 24

TARGET ENVIRONMENTAL SERVICES, INC.
Mobile Laboratories and Direct Push Sampling

December 05, 1998
Teresa White
CH2MHill
625 Herndon Parkway
Herndon, VA 22090

Dear Ms. White:

Enclosed please find the final analytical data report for the NAS-Oceana site, samples collected between10/26/98 and 10/24/98. Water samples were collected by direct push, and submitted to the Target mobile laboratory for GC analysis for VOC's. All samples were analyzed for chlorinated VOC's and BTEX compounds.

Each of the analyses performed has been summarized on tabular data summary pages, along with information about any dilutions performed, and an "S" or "U" flag to indicate either satisfactory or unsatisfactory QA/QC results for that sample. If a result was found to be unsatisfactory, a description of the concern or problem is noted at the bottom of the data summary form.

Following is a summary of specific concerns that may impact data quality, and a description of any corrective actions undertaken.

Initial Calibration

Initial calibration results were within acceptable limits for all contaminants of concern.

Continuing Calibration

Continuing calibration results were within acceptable limits (percent difference less than or equal to 20%) for all target compounds, with the following exceptions, for which the percent difference values exceeded the 20% limit slightly.

10/26/98 - closing CCAL -	11DCE = 22%, CT = 24%, and PCE = 22%
10/28/98 - opening CCAL -	TCE = 23%
closing CCAL -	11DCE = 21%
10/30/98 - opening CCAL -	PCE = 26%

Standards run before and after the out-of-control standards were within control limits.

Blanks

Blanks were run to confirm that sampling procedures and the instrument were not contributing false positive results to the sample analyses. No target compounds were detected in any blank.

Duplicates

Duplicate analyses of field samples were performed to evaluate precision. All duplicate results were within acceptable limits.

Dilutions

Several samples contained elevated concentrations of target compounds, and required dilute analyses to bring the instrument response within the calibration range. Analysis results that exceeded the calibration range have been flagged with an "E" flag. There were also some samples for which target analytes were detected below the reporting limit, but at values greater than the detection limit. These results have been reported as estimated values, and flagged "J".

Please call or E-mail any questions, comments, or concerns you may have.

Sincerely,

Douglas J. McInnes
Laboratory Director
Target Environmental Services, Inc.

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 1-8 (ug/L)	GW 1-14 (ug/L)	GW 1-20 (ug/L)	GW 3-8 (ug/L)	GW 3-14 (ug/L)	GW 3-20 (ug/L)	GW 5-8 (ug/L)	GW 5-14 (ug/L)	GW 5-20 (ug/L)	GW 7-8 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	ND	ND	16.0	ND	ND	363-E	ND	ND	221-E
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	5.40	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	**10X**	**10X**	**10X**	**10X**
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	N/A
Ethylbenzene	5.00	ND	ND	ND	6.47	ND	ND	ND	ND	ND	N/A
m&p-Xylenes	10.0	ND	ND	ND	9.85-J	ND	ND	ND	ND	ND	N/A
o-Xylenes	5.00	ND	ND	ND	20.3	ND	ND	ND	ND	ND	N/A
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	*

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
J: indicates result below detection limit
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit
* N/A indicates not analyzed- not enough sample left for BTEX analysis

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: Jim E. Auld

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 5-8 (ug/L)
1,1-Dichloroethene	5.00	ND
Methylene Chloride	5.00	ND
trans-1,2-Dichloroethene	5.00	ND
1,1-Dichloroethane	5.00	ND
cis-1,2-Dichloroethene	5.00	391
1,1,1-Trichloroethane	0.50	ND
Carbon Tetrachloride	0.50	ND
Trichloroethene	0.50	ND
1,1,2-Trichloroethane	0.50	ND
Tetrachloroethene	0.50	ND
Sample Condition (S,U)/Dilution (PQL)	1	**30X**

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
J: indicates result below detection limit
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: S. Arnold

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 7-14 (ug/L)	GW 7-20 (ug/L)	GW 2-8 (ug/L)	GW 2-14 (ug/L)	GW 2-20 (ug/L)	GW 4-8 (ug/L)	GW 4-14 (ug/L)	GW 4-20 (ug/L)	GW 9-8 (ug/L)	GW 9-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	13.0	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	49.2-J	ND	ND	16.0	ND	ND	106-E	ND	10.1	12.5
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	8.40	ND	ND	ND	ND	ND	3.51-E	ND	ND	3.44-E
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)		10X	10X	100X	S	S	100X	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	6.28	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	ND	ND	89.1	ND	ND	57.2	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	17.0	ND	ND	127	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	6.45	ND	ND	13.6	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: [signature]

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 2-8 (ug/L)	GW 2-8 (ug/L)	GW 4-8 (ug/L)	GW 4-14 (ug/L)	GW 9-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	ND	49.8-J	112	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	ND	6.00	4.55
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	**10X**	S	**10X**	**10X**	**5X**

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 9-20 (ug/L)	GW 6-8 (ug/L)	GW 6-14 (ug/L)	GW 6-20 (ug/L)	GW 13-8 (ug/L)	GW 13-14 (ug/L)	GW 13-20 (ug/L)	GW 14-8 (ug/L)	GW 14-14 (ug/L)	GW 14-20 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	4.85-J	12.8	ND	ND	9.50	ND	ND	9.80	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	49.7-E	128-E	ND	ND	156-E	ND	3.84-J	113-E	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	0.56	0.25-J	ND	ND	11.8-E	ND	ND	7.33-E	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: [signature]

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 6-8 (ug/L)	GW 6-14 (ug/L)	GW 13-14 (ug/L)	GW 14-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	53.5	171	149	155
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	14.4	10.0
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	**5X**	**10X**	**10X**	**10X**

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: Amy S. Auld

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	24 MW-1 (ug/L)	GW 15-8 (ug/L)	GW 15-14 (ug/L)	GW 15-20 (ug/L)	GW 17-8 (ug/L)	GW 17-14 (ug/L)	GW 17-20 (ug/L)	GW 18-8 (ug/L)	GW 18-14 (ug/L)	GW 18-20 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	3.48-J	ND	3.44-J	ND	ND	ND	ND	3.51-J	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	34.1-E	ND	38.7-E	ND	ND	13.1	ND	18.2	ND	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	0.52	ND	ND	1.18	ND	2.53-E	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	5.23	14.0	ND	ND	17.7	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	18.8	ND	ND	9.65	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	*Collected by:*	*Randy Brand*	*Client:*	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	24 MW-1 (ug/L)	GW 15-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND
Methylene Chloride	5.00	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND
1,1-Dichloroethane	5.00	ND	ND
cis-1,2-Dichloroethene	5.00	48.9	46.4
1,1,1-Trichloroethane	0.50	ND	ND
Carbon Tetrachloride	0.50	ND	ND
Trichloroethene	0.50	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND
Tetrachloroethene	0.50	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	5X	5X

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: Jay E. Auld

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 8-8 (ug/L)	GW 8-14 (ug/L)	GW 8-20 (ug/L)	GW 20-8 (ug/L)	GW 20-14 (ug/L)	GW 20-20 (ug/L)	GW 19-8 (ug/L)	GW 19-14 (ug/L)	GW 19-20 (ug/L)	GW 29-8 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	10.4	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	74.0-E	ND	3.41-J	ND	ND	ND	ND	4.91-J	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	4.27-E	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 8-14 (ug/L)
1,1-Dichloroethene	5.00	ND
Methylene Chloride	5.00	ND
trans-1,2-Dichloroethene	5.00	ND
1,1-Dichloroethane	5.00	ND
cis-1,2-Dichloroethene	5.00	93.4
1,1,1-Trichloroethane	0.50	ND
Carbon Tetrachloride	0.50	ND
Trichloroethene	0.50	6.80
1,1,2-Trichloroethane	0.50	ND
Tetrachloroethene	0.50	ND
Sample Condition (S,U)/Dilution (PQL)	1	5X

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 29-14 (ug/L)	GW 29-20 (ug/L)	GW 11-8 (ug/L)	GW 11-14 (ug/L)	GW 11-20 (ug/L)	GW 23-8 (ug/L)	GW 23-14 (ug/L)	GW 23-20 (ug/L)	GW 32-8 (ug/L)	GW 32-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	3.61-J	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	*5.00*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
cis-1,2-Dichloroethene	5.00	33.1-E	ND	ND	59.8-E	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	3.72-E	ND	ND	5.94E	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	*5.00*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 29-14 (ug/L)	GW 11-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND
Methylene Chloride	5.00	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND
1,1-Dichloroethane	5.00	ND	ND
cis-1,2-Dichloroethene	5.00	39.6	80.0
1,1,1-Trichloroethane	0.50	ND	ND
Carbon Tetrachloride	0.50	ND	ND
Trichloroethene	0.50	5.20	9.10
1,1,2-Trichloroethane	0.50	ND	ND
Tetrachloroethene	0.50	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	5X	5X

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 32-20 (ug/L)	GW 36-8 (ug/L)	GW 36-14 (ug/L)	GW 36-20 (ug/L)	GW 31-8 (ug/L)	GW 31-14 (ug/L)	GW 31-20 (ug/L)	GW 10-8 (ug/L)	GW 10-14 (ug/L)	GW 10-20 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	4.84-J	ND	ND	47.2-E	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	ND	ND	ND	0.55	ND	ND	8.01-E	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: Yaz 9. Auld

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 10-14 (ug/L)	GW 10-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND
Methylene Chloride	5.00	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND
1,1-Dichloroethane	5.00	ND	ND
cis-1,2-Dichloroethene	5.00	70.8	ND
1,1,1-Trichloroethane	0.50	ND	ND
Carbon Tetrachloride	0.50	ND	ND
Trichloroethene	0.50	13.8-E	13.4
1,1,2-Trichloroethane	0.50	ND	ND
Tetrachloroethene	0.50	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	5X	10X

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 35-8 (ug/L)	GW 35-14 (ug/L)	GW 35-20 (ug/L)	GW 28-8 (ug/L)	GW 28-14 (ug/L)	GW 28-20 (ug/L)	GW 30-8 (ug/L)	GW 30-14 (ug/L)	GW 30-20 (ug/L)	GW 25-8 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	12.5	ND	ND	ND	ND	ND	ND	11.7	ND	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	ND	ND	1.26	ND	ND	1.17	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: [signature]

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 25-14 (ug/L)	GW 25-20 (ug/L)	GW 24-8 (ug/L)	GW 24-14 (ug/L)	GW 24-20 (ug/L)	GW 27-8 (ug/L)	GW 27-14 (ug/L)	GW 27-20 (ug/L)	GW 12-8 (ug/L)	GW 12-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	52.8-E	ND	ND	175-E	ND	ND	13.0	ND	ND	62.4
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	3.40-E	ND	ND	9.20-E	ND	ND	2.69-E	ND	ND	7.95
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	5X	S	S	S	S	S	5X
Benzene	5.00	ND	ND	ND	N/A	ND	ND	ND	ND	ND	N/A
Toluene	5.00	ND	ND	ND	N/A	ND	ND	ND	ND	ND	N/A
Ethylbenzene	5.00	ND	ND	ND	N/A	ND	ND	ND	ND	ND	N/A
m&p-Xylenes	10.0	ND	ND	ND	N/A	ND	ND	ND	ND	ND	N/A
o-Xylenes	5.00	ND	ND	ND	N/A	ND	ND	ND	ND	ND	N/A
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	*	S	S	S	S	S	*

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit
* N/A indicates not analyzed- not enough sample left for BTEX analysis

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	*Report Revision:*	1.0	*Client Contact:*	*Teresa White*
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 25-14 (ug/L)	GW 24-14 (ug/L)	GW 27-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND
cis-1,2-Dichloroethene	5.00	55.8	174	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND
Trichloroethene	0.50	4.65	15.8	5.50
1,1,2-Trichloroethane	0.50	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	5X	10X	10X

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: Jay S. Auld

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 12-20 (ug/L)	OW24-MW02 (ug/L)	GW 26-8 (ug/L)	GW 26-14 (ug/L)	GW 38-8 (ug/L)	GW 38-14 (ug/L)	GW 200-1 (ug/L)	GW 200-2 (ug/L)	GW 200-3 (ug/L)	GW 46-8 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	24.7-E
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	*10/26-11/15/98*	*Reported by:*	*Stu Johnson Jr.*		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 46-8 (ug/L)
1,1-Dichloroethene	5.00	ND
Methylene Chloride	5.00	ND
trans-1,2-Dichloroethene	5.00	ND
1,1-Dichloroethane	5.00	ND
cis-1,2-Dichloroethene	5.00	28.8
1,1,1-Trichloroethane	0.50	ND
Carbon Tetrachloride	0.50	ND
Trichloroethene	0.50	ND
1,1,2-Trichloroethane	0.50	ND
Tetrachloroethene	0.50	ND
Sample Condition (S,U)/Dilution (PQL)	1	**3X**

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW 46-14 (ug/L)	GW 46-20 (ug/L)	GW 42-8 (ug/L)	GW 42-14 (ug/L)	GW 51-8 (ug/L)	GW 51-14 (ug/L)	GW 51-20 (ug/L)	GW 43-8 (ug/L)	GW 43-14 (ug/L)	GW 41-8 (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	18.7	ND	ND	64.2-E	24.8-E	76.7-E	ND	ND	31.0	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	4.61-E	ND	ND	2.63-E	ND	21.7-E	ND	ND	2.15	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	5X	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	*10/26-11/5/98*	*Received by:*	*Stu Johnson Jr.*	*Client Address:*	*625 Herndon Parkway*
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	*Report Revision:*	*1.0*	*Client Contact:*	*Teresa White*
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	**PQL[3] (ug/L)**	***GW*** **46-14 (ug/L)**	***GW*** **42-14 (ug/L)**	***GW*** **51-8 (ug/L)**	***GW*** **51-14 (ug/L)**
1,1-Dichloroethene	5.00	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	72.9	38.3	83.4
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND
Trichloroethene	0.50	6.11	3.15	ND	27.8
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	**10X**	**5X**	**3X**	**15X**

S: Satisfactory, U: Unsatisfactory

U: see sample narrative

Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: [signature]

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Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	GW *41-14* (ug/L)	GW *21-8* (ug/L)	GW *21-14* (ug/L)	GW *47-8* (ug/L)	GW *47-14* (ug/L)	GW *48-8* (ug/L)	GW *48-14* (ug/L)	GW *48-20* (ug/L)	EB1030 *98-S* (ug/L)	EB1030 *98-B* (ug/L)
1,1-Dichloroethene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	44.7-E	19.1	ND	ND	ND
1,1-Dichloroethane	5.00	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5.00	ND	ND	ND	ND	ND	387-E	257-E	ND	ND	ND
1,1,1-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	0.50	ND	ND	ND	ND	ND	1.18	11.5-E	ND	ND	ND
1,1,2-Trichloroethane	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0.50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	S	S
Benzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Toluene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Ethylbenzene	5.00	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
m&p-Xylenes	10.0	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
o-Xylenes	5.00	ND	ND	ND	ND	ND	ND	ND	ND	N/A	N/A
Sample Condition (S,U)/Dilution (PQL)	1	S	S	S	S	S	S	S	S	*	*

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit
* N/A indicates not analyzed- not enough sample left for BTEX analysis

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010 Sample Analysis Results-RE-RUNS

Compound	PQL[3] (ug/L)	GW 48-8 (ug/L)	GW 48-14 (ug/L)
1,1-Dichloroethene	5.00	ND	ND
Methylene Chloride	5.00	ND	ND
trans-1,2-Dichloroethene	5.00	ND	ND
1,1-Dichloroethane	5.00	ND	ND
cis-1,2-Dichloroethene	5.00	*588*	*269*
1,1,1-Trichloroethane	0.50	ND	ND
Carbon Tetrachloride	0.50	ND	ND
Trichloroethene	0.50	ND	20.4
1,1,2-Trichloroethane	0.50	ND	ND
Tetrachloroethene	0.50	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	**30X**	**30X**

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 3-14 (ug/L)	GW 3-14DUP (ug/L)	% Diff	GW 6-8 (ug/L)	GW 6-8DUP (ug/L)	% Diff
1,1-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
Methylene Chloride	5.00	ND	ND	NA	ND	ND	NA
trans-1,2-Dichloroethene	5.00	ND	ND	NA	4.85	4.97	2%
1,1-Dichloroethane	5.00	ND	ND	NA	ND	ND	NA
cis-1,2-Dichloroethene	5.00	ND	ND	NA	49.7	49.5	0%
1,1,1-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Carbon Tetrachloride	0.50	ND	ND	NA	ND	ND	NA
Trichloroethene	0.50	ND	ND	NA	0.56	0.60	7%
1,1,2-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Tetrachloroethene	0.50	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 19-8 (ug/L)	GW 19-8DUP (ug/L)	% Diff	GW 23-20 (ug/L)	GW 23-20DUP (ug/L)	% Diff
1,1-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
Methylene Chloride	5.00	ND	ND	NA	ND	ND	NA
trans-1,2-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
1,1-Dichloroethane	5.00	ND	ND	NA	ND	ND	NA
cis-1,2-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
1,1,1-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Carbon Tetrachloride	0.50	ND	ND	NA	ND	ND	NA
Trichloroethene	0.50	ND	ND	NA	ND	ND	NA
1,1,2-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Tetrachloroethene	0.50	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 30-20 (ug/L)	GW 30-20 (ug/L)	% Diff	GW 35-8 (ug/L)	GW 35-8 DUP (ug/L)	% Diff
1,1-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
Methylene Chloride	5.00	ND	ND	NA	ND	ND	NA
trans-1,2-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
1,1-Dichloroethane	5.00	ND	ND	NA	ND	ND	NA
cis-1,2-Dichloroethene	5.00	ND	ND	NA	12.5	16.2	26%
1,1,1-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Carbon Tetrachloride	0.50	ND	ND	NA	ND	ND	NA
Trichloroethene	0.50	ND	ND	NA	ND	ND	NA
1,1,2-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Tetrachloroethene	0.50	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 26-8 (ug/L)	GW 26-8DUP (ug/L)	% Diff	GW 47-14 (ug/L)	GW 47-14DUP (ug/L)	% Diff
1,1-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
Methylene Chloride	5.00	ND	ND	NA	ND	ND	NA
trans-1,2-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
1,1-Dichloroethane	5.00	ND	ND	NA	ND	ND	NA
cis-1,2-Dichloroethene	5.00	ND	ND	NA	ND	ND	NA
1,1,1-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Carbon Tetrachloride	0.50	ND	ND	NA	ND	ND	NA
Trichloroethene	0.50	ND	ND	NA	ND	ND	NA
1,1,2-Trichloroethane	0.50	ND	ND	NA	ND	ND	NA
Tetrachloroethene	0.50	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 2-20 (ug/L)	GW 2-20DUP (ug/L)	% Diff	GW 8-14 (ug/L)	GW 8-14 (ug/L)	% Diff
Benzene	5.00	ND	ND	NA	ND	ND	NA
Toluene	5.00	ND	ND	NA	ND	ND	NA
Ethylbenzene	5.00	ND	ND	NA	ND	ND	NA
m&p-Xylenes	10.0	ND	ND	NA	ND	ND	NA
o-Xylenes	5.00	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 15-8 (ug/L)	GW 15-8DUP (ug/L)	% Diff	GW 51-8 (ug/L)	GW 51-8DUP (ug/L)	% Diff
Benzene	5.00	ND	ND	NA	ND	ND	NA
Toluene	5.00	ND	ND	NA	ND	ND	NA
Ethylbenzene	5.00	14.0	14.2	1%	ND	ND	NA
m&p-Xylenes	10.0	18.8	17.7	6%	ND	ND	NA
o-Xylenes	5.00	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 28-8 (ug/L)	GW 28-8DUP (ug/L)	% Diff	GW 35-14 (ug/L)	GW 35-14DUP (ug/L)	% Diff
Benzene	5.00	ND	ND	NA	ND	ND	NA
Toluene	5.00	ND	ND	NA	ND	ND	NA
Ethylbenzene	5.00	ND	ND	NA	ND	ND	NA
m&p-Xylenes	10.0	ND	ND	NA	ND	ND	NA
o-Xylenes	5.00	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 42-8 (ug/L)	GW 42-8DUP (ug/L)	% Diff	GW 7-14 (ug/L)	GW 7-14 (ug/L)	% Diff
Benzene	5.00	ND	ND	NA	ND	ND	NA
Toluene	5.00	ND	ND	NA	ND	ND	NA
Ethylbenzene	5.00	ND	ND	NA	ND	ND	NA
m&p-Xylenes	10.0	ND	ND	NA	ND	ND	NA
o-Xylenes	5.00	ND	ND	NA	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Duplicate Analysis Results in ug/L

Compound	PQL[3] (ug/L)	GW 48-20 (ug/L)	GW 48-20DUP (ug/L)	% Diff
Benzene	5.00	ND	ND	NA
Toluene	5.00	ND	ND	NA
Ethylbenzene	5.00	ND	ND	NA
m&p-Xylenes	10.0	ND	ND	NA
o-Xylenes	5.00	ND	ND	NA
Sample Condition (S,U)/Dilution (PQL)		S	S	

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

ND indicates that no analyte was detected at or above the practical quantitation limit
NA indicates that the calculation is not applicable

SAMPLE NARRATIVE:

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	625 Herndon Parkway
Samples Analyzed:	10/26-11/15/98	Analyzed by:	Stu Johnson Jr.		Herdon, VA
Samples Reported:	10/26-11/15/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	1.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	703-481-0980

USEPA Method 3810/8010-8020 Sample Analysis Results

Compound	PQL[3] (ug/L)	24PZ 3S (ug/L)	24PZ 3D (ug/L)
1,1-Dichloroethene	5.00	7.77	7.00
Methylene Chloride	5.00	ND	ND
trans-1,2-Dichloroethene	5.00	3.41 J	47.3 E
1,1-Dichloroethane	5.00	ND	ND
cis-1,2-Dichloroethene	5.00	29.8 E	339 E
1,1,1-Trichloroethane	0.50	ND	ND
Carbon Tetrachloride	0.50	ND	ND
Trichloroethene	0.50	1.68	0.57
1,1,2-Trichloroethane	0.50	ND	ND
Tetrachloroethene	0.50	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S
Benzene	5.00	ND	ND
Toluene	5.00	ND	ND
Ethylbenzene	5.00	ND	ND
m&p-Xylenes	10.0	ND	ND
o-Xylenes	5.00	ND	ND
Sample Condition (S,U)/Dilution (PQL)	1	S	S

S: Satisfactory, U: Unsatisfactory
U: see sample narrative
Dilution: numerical dilution factor used to quantitate analyte concentrations within the range of the initial calibration curve

[3] PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable
ND indicates that no analyte was detected at or above the practical quantitation limit

SAMPLE NARRATIVE: samples flagged with "J" indicates result below detection limit, although reported, result is estimated
samples flagged with "E" indicates result exceeded calibration range, although reported, result is estimated

Quality Control Analyst: _____

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Initial Calibration 10/26/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
AREA COUNTS										
1nd Level Standard	21.38	0.880	0.870	0.570	0.360	25.97	117.1	11.44	0.320	49.8
2rd Level Standard	37.16	1.38	2.000	1.540	0.690	65.27	273.6	25.68	0.61	119.6
3th Level Standard	48.97	2.91	3.62	2.59	1.020	103.6	438.6	42.6	1.03	167.1
CONCENTRATION										
1nd Level Standard	5.00	5.00	5.00	5.00	5.00	0.50	0.50	0.50	0.50	0.50
2rd Level Standard	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
3th Level Standard	20.0	20.0	20.0	20.0	20.0	2.00	2.00	2.00	2.00	2.00
CALIBRATION FACTORS										
1nd Level Standard	4.276	0.176	0.174	0.114	0.072	51.9	234.1	22.88	0.64	99.7
2rd Level Standard	3.716	0.138	0.200	0.154	0.069	65.3	273.6	25.68	0.61	119.6
3th Level Standard	2.449	0.146	0.181	0.130	0.051	51.8	219.3	21.29	0.52	93.6
AVG. CAL. FACTOR	3.4802	0.1532	0.1850	0.1325	0.0640	56.337	242.330	23.282	0.588	104.285
STD. DEV. OF CAL. FAC.	0.936	0.020	0.013	0.020	0.011	7.737	28.065	2.225	0.065	13.619
% RSD	26.9%	13.1%	7.3%	15.2%	17.7%	13.7%	11.6%	9.6%	11.1%	13.1%

USEPA Method 3810-8020 Initial Calibration 11/9/98

STANDARD ANALYTES	Benzene	Toluene	Ethylbenzene	m&p-Xylene	o-Xylene
AREA COUNTS					
1st Level Standard	0.27	0.25	0.22	0.42	0.23
2nd Level Standard	0.89	0.88	0.87	1.70	0.79
3rd Level Standard	1.73	1.78	1.71	3.21	1.54
4th Level Standard	3.19	3.19	3.30	6.20	2.28
5th Level Standard	4.46	4.63	4.84	9.31	3.75
CONCENTRATIONS					
1st Level Standard	5.00	5.00	5.00	10.0	5.00
2nd Level Standard	25.0	25.0	25.0	50.0	25.0
3rd Level Standard	50.0	50.0	50.0	100	50.0
4th Level Standard	75.0	75.0	75.0	150	75.0
5th Level Standard	100	100	100	200	100
CALIBRATION FACTORS					
1st Level Standard	0.0540	0.0500	0.0440	0.0420	0.0460
2nd Level Standard	0.0356	0.0352	0.0348	0.0340	0.0316
3rd Level Standard	0.0346	0.0356	0.0342	0.0321	0.0308
4th Level Standard	0.0425	0.0425	0.0440	0.0413	0.0304
5th Level Standard	0.0446	0.0463	0.0464	0.0466	0.0375
AVG. CAL. FACTOR	0.0423	0.0419	0.0411	0.0392	0.0353
STD. DEV. OF CAL. FAC.	0.0078	0.0065	0.0063	0.0060	0.0067
% RSD	18.6%	15.5%	15.3%	15.3%	18.9%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 10/26/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	31.070	1.640	1.750	1.430	0.710	54.800	229.960	24.320	0.560	123.510
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	3.107	0.164	0.175	0.14300	0.071	54.8	229.96	24.32	0.56	123.51
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	11%	7%	5%	8%	11%	3%	5%	4%	5%	18%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 10/26/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	27.160	1.570	1.950	1.440	0.610	45.520	183.880	20.250	0.660	81.730
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.716	0.157	0.195	0.144	0.061	45.52	183.88	20.25	0.6600	81.73
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	22%	3%	5%	9%	5%	19%	24%	13%	12%	22%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/[illegible]/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 10/27/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	29.570	1.440	1.840	1.250	0.580	57.100	230.610	22.600	0.500	102.450
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.957	0.144	0.184	0.12500	0.058	57.1	230.61	22.6	0.5	102.45
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	15%	6%	1%	6%	9%	1%	5%	3%	15%	2%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 10/27/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	32.230	1.670	1.670	1.380	0.750	63.850	243.860	27.340	0.680	113.420
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	3.223	0.167	0.167	0.138	0.075	63.85	243.86	27.34	0.6800	113.42
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	7%	9%	10%	4%	17%	13%	1%	17%	16%	9%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 10/28/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	33.610	1.690	1.670	1.360	0.630	64.580	266.000	28.700	0.580	125.000
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	3.361	0.169	0.167	0.13600	0.063	64.58	266	28.7	0.58	125
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	3%	10%	10%	3%	2%	15%	10%	23%	1%	20%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 10/28/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	27.400	1.660	2.020	1.110	0.610	46.100	200.500	19.820	0.630	82.940
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.74	0.166	0.202	0.111	0.061	46.1	200.5	19.82	0.6300	82.94
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	21%	8%	9%	16%	5%	18%	17%	15%	7%	20%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 10/29/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	28.000	1.580	1.740	1.370	0.640	61.320	234.970	19.720	0.570	123.020
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.8	0.158	0.174	0.13700	0.064	61.32	234.97	19.72	0.57	123.02
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	20%	3%	6%	3%	0%	9%	3%	15%	3%	18%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 10/29/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	31.840	1.680	1.990	1.140	0.620	53.230	241.000	19.350	0.510	94.780
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	3.184	0.168	0.199	0.114	0.062	53.23	241	19.35	0.5100	94.79
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	9%	10%	8%	14%	3%	6%	1%	17%	13%	9%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 10/30/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	29.620	1.580	1.850	1.080	0.550	53.230	233.000	18.710	0.610	77.010
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.962	0.158	0.185	0.10800	0.055	53.23	233	18.71	0.61	77.01
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	15%	3%	0%	18%	14%	6%	4%	20%	4%	26%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 10/30/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	36.800	1.480	1.930	1.430	0.610	61.860	287.100	25.200	0.620	117.600
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	3.68	0.148	0.193	0.143	0.061	61.86	287.1	25.2	0.6200	117.6
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	6%	3%	4%	8%	5%	10%	18%	8%	5%	13%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 11/2/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	*29.660*	*1.790*	*1.770*	*1.290*	*0.620*	*54.800*	*218.000*	*25.170*	*0.580*	*110.350*
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.966	0.179	0.177	0.12900	0.062	54.8	218	25.17	0.58	110.35
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	15%	17%	4%	3%	3%	3%	10%	8%	1%	6%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 11/2/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	29.890	1.430	1.600	1.220	0.690	49.010	212.550	22.000	0.620	99.020
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.989	0.143	0.16	0.122	0.069	49.01	212.55	22	0.6200	99.02
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	14%	7%	14%	8%	8%	13%	12%	6%	5%	5%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 11/3/98-opening

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	32.900	1.610	1.680	1.360	0.630	61.930	251.340	26.610	0.570	115.160
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	3.29	0.161	0.168	0.13600	0.063	61.93	251.34	26.61	0.57	115.16
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	5%	5%	9%	3%	2%	10%	4%	14%	3%	10%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 11/3/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	28.640	1.530	1.900	1.510	0.580	60.520	229.100	22.320	0.620	98.400
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.864	0.153	0.19	0.151	0.058	60.52	229.1	22.32	0.6200	98.4
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	18%	0%	3%	14%	9%	7%	5%	4%	5%	6%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	*Collected by:*	*Randy Brand*	*Client:*	*CH2MHill*
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8010 Continuing Calibration Check 11/3/98

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	32.900	1.610	1.680	1.360	0.630	61.930	251.340	26.610	0.570	115.160
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	3.29	0.161	0.168	0.13600	0.063	61.93	251.34	26.61	0.57	115.16
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	5%	5%	9%	3%	2%	10%	4%	14%	3%	10%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8010 Continuing Calibration Check 11/3/98-closing

STANDARD ANALYTES	11DCE	MeCl2	t12DCE	11DCA	c12DCE	111TCA	CT	TCE	112TCA	PCE
Continuing Area Count	28.640	1.530	1.900	1.510	0.580	60.520	229.100	22.320	0.620	98.400
Concentration	10.0	10.0	10.0	10.0	10.0	1.00	1.00	1.00	1.00	1.00
Continuing Cal Factor	2.864	0.153	0.19	0.151	0.058	60.52	229.1	22.32	0.6200	98.4
Average Cal Factor (Initial)	3.4802	0.1532	0.1850	0.1325	0.0640	56.3367	242.3300	23.2817	0.5883	104.2850
Percent Difference	18%	0%	3%	14%	9%	7%	5%	4%	5%	6%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8020 Continuing Calibration Check 11/9/98-closing

STANDARD ANALYTES	Benzene	Toluene	Ethybenzene	m&p-Xylene	o-Xylene
Continuing Area Count	1.80	1.75	1.94	3.63	1.47
Standard Area Count	1.73	1.78	1.71	3.21	1.54
Percent Difference	4%	-2%	13%	13%	-5%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8020 Continuing Calibration Check 11/11/98-opening

STANDARD ANALYTES	Benzene	Toluene	Ethyl benzene	m&p-Xylene	o-Xylene
Continuing Area Count	1.80	1.75	1.94	3.63	1.47
Standard Area Count	1.73	1.78	1.71	3.21	1.54
Percent Difference	4%	-2%	13%	13%	-5%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

USEPA Method 3810-8020 Continuing Calibration Check 11/11/98

STANDARD ANALYTES	Benzene	Toluene	Ethybenzene	m&p-Xylene	o-Xylene
Continuing Area Count	1.74	1.87	1.57	2.91	1.35
Standard Area Count	1.73	1.78	1.71	3.21	1.54
Percent Difference	1%	5%	-8%	-9%	-12%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

Samples Collected:	10/26-11/4/98	Collected by:	Randy Brand	Client:	CH2MHill
Samples Received:	10/26-11/5/98	Received by:	Stu Johnson Jr.	Client Address:	Herdon Va.
Samples Analyzed:	10/26-11/13/98	Analyzed by:	Stu Johnson Jr.		0
Samples Reported:	10/26-11/13/98	Reported by:	Stu Johnson Jr.		
Project Identification:	NAS OCEANA	Report Revision:	0.0	Client Contact:	Teresa White
Target Job Code:	CHH10138	Method Deviations:	None	Client Phone:	703-471-6405
Purchase Order:	N/A	Sampling Method:	GEOPROBE	Client Fax:	0

USEPA Method 3810-8020 Continuing Calibration Check 11/11/98-closing

STANDARD ANALYTES	Benzene	Toluene	Ethybenzene	m&p-Xylene	o-Xylene
Continuing Area Count	1.98	1.94	1.96	3.77	1.48
Standard Area Count	1.73	1.78	1.71	3.21	1.54
Percent Difference	14%	9%	16%	17%	-5%
QC Range	+/- 20%	+/- 20%	+/- 20%	+/- 20%	+/- 20%

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHH10138

CLIENT: CH2M HILL
ADDRESS: HERNDON, VA
PHONE: 703-471-6405 x 4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: ROBINSON

DATE: 10/26/98 PAGE 1 OF
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BRAND DATE OF COLLECTION: 10/26/98

Sample Number	Depth	Time	Sample Type	Container Type	VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW 1-8	8'	1115	GW	40ml VOA	X																	Heavy sediment (SILTY)	2	✓
GW 1-14	14'	1125	H2O	40ml VOA	X																	SILTY	2	✓
GW 1-20	20'	1144	H2O	40ml VOA	X																	SILTY	2	✓
GW 3-8	8'	1230	H2O	40ml VOA	X																	SILTY	2	✓
GW 3-14	14'	1315	H2O																			SILTY	2	✓
GW 3-20	20'	1345	H2O																			SILTY	2	✓
GW 5-8	8'	1440	H2O																			SILTY	2	✓
GW 5-14	14'		"																			"	2	✓
GW 5-20	20'		"																			"	2	✓
GW 7-8	8'		"																			"	2	✓
GW 7-14	14'		"																			"	2	✓
GW 7-20	20'		"																			"	2	✓
																						"		
																						"		
																						"		
																						"		
																						"		
																						"		

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
Randy Brand	10/26/98 1800		10/27/98 1810
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	12
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHH 10138

CLIENT: CH2M HILL
ADDRESS: HERNDON VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: Robinson

DATE: 10/27/98 PAGE 1 OF
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BRAND DATE OF COLLECTION: 10/27/98

Sample Number	(FT) Depth	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW9-8	8	0820	H2O	40ML VOA	X																	SILTY	2	
-14	14	0840																					2	
-20	20	0850																					2	
GW4-8	8	0920																				Heavy Silt + SMELLY	2	
GW4-14	14	0938																				SILTY	2	
GW4-20	20	1030																				"	2	
GW2-8	8	1050																				" + SMELLY	2	
GW2-14	14	1110																				"	2	
GW2-20	20	1140																				"	2	
GW6-8	8	1205																				"	2	
GW6-14	14	1220																				"	2	
GW6-20	20	1230																				"	2	
GW13-8	8	1400																				"	2	
-14	14	"																				"	2	
-20	20	"																				"	2	
GW14-8	8	1435																				"	2	
-14	14	1445																				"	2	
-20	20	1455																				"	2	

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
	10/27/98 1600		10/27/98 1730
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	36
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHH 10138

CLIENT: CH2M HILL
ADDRESS: HERNDON VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: ROBINSON

DATE: 10/27/98 PAGE 2 OF 1
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BRAND DATE OF COLLECTION: 10/27/98

Sample Number	(FT) Depth	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
(53) ~~GW~~ 24MW-1	—	1513	H2O	40ML VOA	X																	MONITORING WELL SAMPLE	2	✓
GW 15-8	8	1555																				SILTY	2	✓
GW 15-14	14	1555																				"	2	✓
GW 15-20	20	1615																				"	2	✓
GW 17-8	8	1705																				"	2	✓
GW 17-14	14	1715																				"	2	✓
GW17-20	20	1730																				"	2	✓

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
[signature]	10/27/98 1730	[signature]	10/27/98 1730
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: QHH10138

CLIENT: CH2M HILL
ADDRESS: HERNDON VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: ROBINSON

DATE: 10/28/98 PAGE 1 OF 2
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BRAND DATE OF COLLECTION: 10/28/98

Sample Number	Depth (FT)	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	TPH 8015 (q & d)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW18-8	8	0840	H2O	40mL VOA	X																		SILTY	2	✓
-14	14																						SOME SILT	2	✓
-20	20																						" "	2	✓
GW8-8	8	0945																					SILTY	2	✓
-14	14																						"	2	✓
-20	20																						"	2	✓
GW20-8	8	1050																					"	2	✓
-14	14	1050																					"	2	✓
-20	20	1110																					"	2	✓
GW19-8	8	1210																					"	2	✓
-14	14	1210																					"	2	✓
-20	20	1210																					"	2	✓
GW29-8	8	1320																					"	2	✓
-14	14	1320																					"	2	✓
-20	20	1320																					"	2	✓
GW11-8	8	1430																					"	2	✓
-14	14																						"	2	✓
-20	20																						"	2	✓

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
	10/28/98 1500		10/28/98
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	36
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHH10138

CLIENT: CH2M HILL
ADDRESS: HERNDON VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: ROBINSON

DATE: 10/28/98 PAGE 2 OF 2
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BRAND DATE OF COLLECTION: 10/28/98

Sample Number	Depth (FT)	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW 23-8	8	1530	H2O	40ml VOA	X																	SILTY	2	✓
" -14	14	1540																				"	2	✓
" -20	20	1600																				"	2	✓
GW 32-8	8	1640																				"	2	✓
" -14	14	1640																				"	2	✓
" -20	20	1650																				"	2	✓

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[signature]	10/28/98 1740	[signature]	10/28/98
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CH4 10138

CLIENT: CH2M Hill
ADDRESS: Herndon VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: Robinson

DATE: 10/29/98 PAGE 1 OF 2
P.O.# :
LOCATION: NAS Oceana
COLLECTOR: Randy Brand DATE OF COLLECTION: 10/29/98

Sample Number	Depth (FT)	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	TPH 8015 (oil & gl)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW36-8	8	0720	H2O	40 mL VOA	X																		Silty	2	✓
-14	14	0735																					"	2	✓
-20	20	0745																					"	2	✓
GW31-8	8	0835																					"	2	✓
-14	14	0835																					"	2	✓
-20	20	0910																					"	2	✓
GW10-8	8	0950																					"	2	✓
-14	14	0950																					"	2	✓
-20	20	1010																					"	2	✓
GW35-8	8	1100																					"	2	✓
-14	14	1100																					"	2	✓
-20	20	1120																					"	2	✓
GW2-8	8	1215																					" (RESAMPLE)	2	✓
GW28-8	8	1240																					"	2	✓
-14	14	1330																					"	2	✓
-20	20	1330																					"	2	✓
GW30-8	8	1410																					"	2	✓
-14	14	1415																					"	2	✓

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
Teresa G. White	10/29/98 1500		10/29/98
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	36
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHH10138

CLIENT: CH2M Hill
ADDRESS: Herndon VA
PHONE: (703) 471-6405 x4326 FAX:
CLIENT PROJECT #: PROJECT MANAGER: Rhanson

DATE: 10/29/98 PAGE 2 OF 2
P.O.# :
LOCATION: NAS Oceana
COLLECTOR: Randy Brand DATE OF COLLECTION: 10/29/98

Sample Number	(FT) Depth	Time	Sample Type	Container Type	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW30-20	20	1450	H2O	40mL VOA	Sicky	2	✓
GW25-8	8	1525			"	2	✓
GW25-14	14	1535			"	2	✓
" -20	20	1555			"	2	✓
GW24-8	8	1650			"	2	✓
" -14	14	1650			"	2	✓
" -20	20	1710			"	2	✓

ANALYSES: VOA 601/8010; VOA 602/8020; VOA 624/8260; Semi Vol 625/8270; TPH 418.1; TPH 8015 (gasoline); TPH 8015 (diesel); PNA 610/8100; PEST/PCBs 8080; TOC; BOD; LEAD 239.2; pH; Ignitability; Metals 6000/7000; Reactivity; Preservative (Y/N)

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
[signature]	10/29/98 1415	[signature]	10/29/98
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	14
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHH10138

CLIENT: CH2M HILL
ADDRESS: VERNDON VA
PHONE: (703) 471-6405 x432 FAX:
CLIENT PROJECT #: PROJECT MANAGER: Robinson

DATE: 10/30/98 PAGE 1 OF 2
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BRAND DATE OF COLLECTION: 10/30/98

Sample Number	(FT) Depth	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	TPH 8015 (g & d)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW27-8	8	0730	H2O	40ml VOA	X																		Silty	2	✓
" -14	14	0735																					"	2	✓
" -20	20	0800																					"	2	✓
GW12-8	8	0845																					"	2	✓
" -14	14	0845																					"	2	✓
" -20	20	0845																					"	2	✓
OW24-MW02	—	0845																					Monitoring Well	2	✓
EB103098-S	—	0915																					Equip Blank	2	✓
EB103098-B	—	0915																					Screen Blank	2	✓
GW26-8	8	0945																					Silty	2	✓
" -14	14	0945																					Silty	2	✓
GW38-8	8	1020																					"	2	✓
" -14	14	1020																					"	2	✓
GW200-1	—	1310																					Different Location	2	✓
" -2	—	1310																					"	2	✓
" -3	—	1310																					"	2	✓

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
[signature]	10/30/98 1330	[signature]	10/30/98
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: RHH 10138

CLIENT: CH2M HILL
ADDRESS: HERNDON VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: Robinson

DATE: 10/30/98 PAGE 2 OF 2
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BEARD DATE OF COLLECTION: 10/30/98

Sample Number	(FT) Depth	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	TPH 8015 (g & d)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW46-8	8	1430	H2O	40mL VOA	X																		Silty	2	✓
" -14	14	"	"	"																			"	2	✓
" -20	20	"	"	"																			"	2	✓
GW42-8	8	1530	"	"																			"	2	✓
" -14	14	"	"	"																			"	2	✓

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
[signature]	1600 10/30/98	[signature]	10/30/98
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHM10138

CLIENT: CH2M HILL
ADDRESS: HERNDON VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: Robinson

DATE: 11/2/98 PAGE 1 OF 1
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: Randy BRAND DATE OF COLLECTION: 11/2/98

Sample Number	Depth (FT)	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW51-8	8	1550	H_2O	40mL VOA	X																	Silty	2	✓
" -14	14	"	"	"																		"	2	✓
" -20	20	1620	"	"																		"	2	✓
GW42-8	8	1650	"	"																		Re-Sample	2	✓

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
[signature]	11/2/98 1800	[signature]	11/2/98 1840
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	8
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

10555 Guilford Rd. Suite 127, Jessup, Md 20794
Office: 301-497-6400 Fax: 301-497-4440

CHAIN-OF-CUSTODY RECORD

JOB CODE: CHM10138

CLIENT: CH2M HILL
ADDRESS: HERNDON VA
PHONE: (703) 471-6405 x4321 FAX:
CLIENT PROJECT #: PROJECT MANAGER: Robinson

DATE: 11/3/98 PAGE OF
P.O.# :
LOCATION: NAS OCEANA
COLLECTOR: RANDY BRAND DATE OF COLLECTION: 11/3/98

Sample Number	Depth (FT)	Time	Sample Type	Container Type	ANALYSES: VOA 601/8010	VOA 602/8020	VOA 624/8260	Semi Vol 625/8270	TPH 418.1	TPH 8015 (gasoline)	TPH 8015 (diesel)	TPH 8015 (g & d)	PNA 610/8100	PEST/PCBs 8080	TOC	BOD	LEAD 239.2	pH	Ignitability	Metals 6000/7000	Reactivity	Preservative (Y/N)	FIELD NOTES	Total Number of Containers	Laboratory Note Number
GW43-8	8	0825	H2O	40 mL VOA	X																		SILTY	2	✓
" -14	14	0845																					SILTY	2	✓
GW41-8	8	0950																					"	2	✓
" -14	14	0950																					"	2	✓
GW41-8	8	1030																					"	2	✓
GW47-8	8	1150																					"	2	✓
" -14	14	1210																					"	2	✓
GW48-8	8	1305																					"	2	✓
" -14	14	1305																					"	2	✓
" -20	20	1310																					"	2	✓
GW31-14	14	—																					WAS left off CHAIN (SB) 12/3/98		
(SB)																									

RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME
[signature]	11/3/98 1830	[signature]	11/3/98 1330
RELINQUISHED BY: (Signature)	DATE/TIME	RECEIVED BY: (Signature)	DATE/TIME

SAMPLE RECEIPT	
Total Number of Containers	20
Chain of Custody Seals Y/N NA	
Seals Intact? Y/N NA	
Received Good Cond./Cold	
Notes:	

LABORATORY NOTES:

TARGET LABORATORIES

~~GP ENVIRONMENTAL SERVICES, INC.~~

~~202 Perry Parkway~~
~~Gaithersburg, Maryland 20877~~
~~(301) 926-6802~~

Contract #/Billing Reference: CHH10138

1 of 1 Pgs.

Project: NAS OCEANA
Client: CH2M HILL
Send Results To: JACK ROBINSON
Address: 625 HERNDON PARKWAY
HERNDON, VA 20170
Phone: (703) 471-1441

Sample ID#	Date Sampled	Time Sampled	Sample Matrix	Sampler's Initials	Turnaround Time	# of Containers	Container Type	Preservative Used	Type of Analysis		Lab Cooler No.	CLIENT COMMENTS
									VOCs	BETX		
24-PZ3S	11/4/98		H_2O	TW	7-DAY	2	40ml	HCl	X	X		
24-PZ3D	11/4/98		H_2O	TW	7-DAY	2	40ml	HCl	X	X		

Relinquished By:	Date/Time	Received By:	Relinquished By:	Received for Laboratory By:	Date/Time
[signature]	11/4/98 1800	[signature]		[signature]	11/5/98 1350
Relinquished By:	Date/Time	Received By:	Date/Time / Shipper:	Airbill No.:	
Relinquished By:	Date/Time	Received By:	Lab Comments:	Temp:	

G.P. W.O. _____

Appendix A-2

Summary of Detected Chemicals for Groundwater Sampling at SWMU 24

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW01-R01	10/27/98	1,1,2-TRICHLOROETHANE	2.40		UG/L	1.00
OW24-MW01-R01	10/27/98	2-METHYLNAPHTHALENE	11.00	J	UG/L	11.00
OW24-MW01-R01	10/27/98	ALUMINUM	291.00	B	UG/L	40.80
OW24-MW01-R01	10/27/98	ANTHRACENE	1.10	J	UG/L	0.10
OW24-MW01-R01	10/27/98	ARSENIC	48.60		UG/L	3.00
OW24-MW01-R01	10/27/98	ARSENIC	49.10		UG/L	3.00
OW24-MW01-R01	10/27/98	BARIUM	32.30	J	UG/L	0.40
OW24-MW01-R01	10/27/98	BARIUM	35.50	J	UG/L	0.40
OW24-MW01-R01	10/27/98	BENZENE	2.00		UG/L	1.00
OW24-MW01-R01	10/27/98	CALCIUM	30800.00		UG/L	28.00
OW24-MW01-R01	10/27/98	CALCIUM	32900.00		UG/L	28.00
OW24-MW01-R01	10/27/98	CHROMIUM	1.80	J	UG/L	0.70
OW24-MW01-R01	10/27/98	CHROMIUM	2.30	J	UG/L	0.70
OW24-MW01-R01	10/27/98	CIS-1,2-DICHLOROETHENE	59.80	J	UG/L	1.00
OW24-MW01-R01	10/27/98	COPPER	2.00	B	UG/L	0.60
OW24-MW01-R01	10/27/98	COPPER	4.50	B	UG/L	0.60
OW24-MW01-R01	10/27/98	DIBENZOFURAN	3.00	J	UG/L	11.00
OW24-MW01-R01	10/27/98	ETHYLBENZENE	7.60		UG/L	1.00
OW24-MW01-R01	10/27/98	FLUORANTHENE	14.00	J	UG/L	1.00
OW24-MW01-R01	10/27/98	IRON	16400.00		UG/L	23.50
OW24-MW01-R01	10/27/98	IRON	17700.00		UG/L	23.50
OW24-MW01-R01	10/27/98	MAGNESIUM	11700.00		UG/L	24.20
OW24-MW01-R01	10/27/98	MAGNESIUM	12400.00		UG/L	24.20
OW24-MW01-R01	10/27/98	MANGANESE	479.00		UG/L	1.10
OW24-MW01-R01	10/27/98	MANGANESE	514.00		UG/L	1.10
OW24-MW01-R01	10/27/98	NAPHTHALENE	15.00		UG/L	2.10
OW24-MW01-R01	10/27/98	NICKEL	2.40	L	UG/L	1.30
OW24-MW01-R01	10/27/98	PHENANTHRENE	0.93	J	UG/L	0.05
OW24-MW01-R01	10/27/98	POTASSIUM	4130.00	J	UG/L	20.20
OW24-MW01-R01	10/27/98	POTASSIUM	4410.00	J	UG/L	20.20
OW24-MW01-R01	10/27/98	PYRENE	0.01	B	UG/L	0.01
OW24-MW01-R01	10/27/98	SODIUM	11700.00		UG/L	210.00
OW24-MW01-R01	10/27/98	SODIUM	12100.00		UG/L	210.00
OW24-MW01-R01	10/27/98	TRANS-1,2-DICHLOROETHENE	8.80		UG/L	1.00
OW24-MW01-R01	10/27/98	VANADIUM	2.50	B	UG/L	0.80
OW24-MW01-R01	10/27/98	VANADIUM	3.20	B	UG/L	0.80
OW24-MW01-R01	10/27/98	ZINC	15.60	B	UG/L	2.00
OW24-MW01-R01	10/27/98	ZINC	22.40	B	UG/L	2.00
OW24-MW02F-R01	10/30/98	ALUMINUM	51.6000	B	UG/L	40.8000
OW24-MW02F-R01	10/30/98	ANTIMONY	5.0000	J	UG/L	4.2000
OW24-MW02F-R01	10/30/98	BARIUM	46.5000	J	UG/L	0.4000
OW24-MW02F-R01	10/30/98	CALCIUM	33800.0000		UG/L	28.0000
OW24-MW02F-R01	10/30/98	CHROMIUM	0.7100	B	UG/L	0.7000
OW24-MW02F-R01	10/30/98	COBALT	1.3000	J	UG/L	0.6000
OW24-MW02F-R01	10/30/98	COPPER	22.4000	B	UG/L	0.6000
OW24-MW02F-R01	10/30/98	IRON	1030.0000		UG/L	23.5000
OW24-MW02F-R01	10/30/98	MAGNESIUM	3730.0000	J	UG/L	24.2000
OW24-MW02F-R01	10/30/98	MANGANESE	42.5000		UG/L	1.1000
OW24-MW02F-R01	10/30/98	NICKEL	10.1000	B	UG/L	1.3000
OW24-MW02F-R01	10/30/98	POTASSIUM	6500.0000		UG/L	20.2000
OW24-MW02F-R01	10/30/98	SODIUM	9950.0000		UG/L	210.0000
OW24-MW02F-R01	10/30/98	VANADIUM	1.6000	J	UG/L	0.8000
OW24-MW02F-R01	10/30/98	ZINC	62.2000	B	UG/L	2.0000
OW24-MW02PF-RC	10/30/98	ALUMINUM	53.8000	B	UG/L	40.8000
OW24-MW02PF-RC	10/30/98	ARSENIC	3.0000	J	UG/L	3.0000
OW24-MW02PF-RC	10/30/98	BARIUM	54.1000	J	UG/L	0.4000
OW24-MW02PF-RC	10/30/98	CALCIUM	39000.0000		UG/L	28.0000
OW24-MW02PF-RC	10/30/98	CHROMIUM	1.3000	B	UG/L	0.7000
OW24-MW02PF-RC	10/30/98	COBALT	1.6000	J	UG/L	0.6000
OW24-MW02PF-RC	10/30/98	COPPER	32.3000	B	UG/L	0.6000
OW24-MW02PF-RC	10/30/98	IRON	1290.0000		UG/L	23.5000
OW24-MW02PF-RC	10/30/98	LEAD	1.8000	J	UG/L	1.7000

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW02PF-RC	10/30/98	MAGNESIUM	4280.0000	J	UG/L	24.2000
OW24-MW02PF-RC	10/30/98	MANGANESE	48.9000		UG/L	1.1000
OW24-MW02PF-RC	10/30/98	NICKEL	14.8000	B	UG/L	1.3000
OW24-MW02PF-RC	10/30/98	POTASSIUM	7380.0000		UG/L	20.2000
OW24-MW02PF-RC	10/30/98	SODIUM	11600.0000		UG/L	210.0000
OW24-MW02PF-RC	10/30/98	VANADIUM	1.5000	J	UG/L	0.8000
OW24-MW02PF-RC	10/30/98	ZINC	72.4000	B	UG/L	2.0000
OW24-MW02P-R01	10/30/98	ACENAPHTHYLENE	5.2000		UG/L	1.1000
OW24-MW02P-R01	10/30/98	ALUMINUM	2110.0000		UG/L	40.8000
OW24-MW02P-R01	10/30/98	ARSENIC	5.8000	J	UG/L	3.0000
OW24-MW02P-R01	10/30/98	BARIUM	81.2000	J	UG/L	0.4000
OW24-MW02P-R01	10/30/98	BENZO(A)ANTHRACENE	0.0160		UG/L	0.0110
OW24-MW02P-R01	10/30/98	BERYLLIUM	0.4500	B	UG/L	0.2000
OW24-MW02P-R01	10/30/98	CADMIUM	0.5400	B	UG/L	0.4000
OW24-MW02P-R01	10/30/98	CALCIUM	38700.0000		UG/L	28.0000
OW24-MW02P-R01	10/30/98	CHROMIUM	12.4000	B	UG/L	0.7000
OW24-MW02P-R01	10/30/98	CHRYSENE	0.0170		UG/L	0.0110
OW24-MW02P-R01	10/30/98	CIS-1,2-DICHLOROETHENE	0.2000	J	UG/L	1.0000
OW24-MW02P-R01	10/30/98	COBALT	3.2000	J	UG/L	0.6000
OW24-MW02P-R01	10/30/98	COPPER	10.5000	B	UG/L	0.6000
OW24-MW02P-R01	10/30/98	FLUORENE	0.3900	J	UG/L	0.4300
OW24-MW02P-R01	10/30/98	IRON	3060.0000		UG/L	23.5000
OW24-MW02P-R01	10/30/98	LEAD	11.1000		UG/L	1.7000
OW24-MW02P-R01	10/30/98	MAGNESIUM	4380.0000	J	UG/L	24.2000
OW24-MW02P-R01	10/30/98	MANGANESE	57.3000		UG/L	1.1000
OW24-MW02P-R01	10/30/98	METHYLENE CHLORIDE	0.3000	B	UG/L	2.0000
OW24-MW02P-R01	10/30/98	NAPHTHALENE	0.3200	J	UG/L	2.2000
OW24-MW02P-R01	10/30/98	NICKEL	31.8000	B	UG/L	1.3000
OW24-MW02P-R01	10/30/98	PHENANTHRENE	0.0400	B	UG/L	0.0540
OW24-MW02P-R01	10/30/98	POTASSIUM	7160.0000		UG/L	20.2000
OW24-MW02P-R01	10/30/98	PYRENE	0.0060	B	UG/L	0.0050
OW24-MW02P-R01	10/30/98	SODIUM	10700.0000		UG/L	210.0000
OW24-MW02P-R01	10/30/98	VANADIUM	8.8000	J	UG/L	0.8000
OW24-MW02P-R01	10/30/98	ZINC	104.0000	B	UG/L	2.0000
OW24-MW02-R01	10/30/98	4,4'-DDD	0.0420	B	UG/L	0.2000
OW24-MW02-R01	10/30/98	4,4'-DDE	0.0090	B	UG/L	0.2000
OW24-MW02-R01	10/30/98	4,4'-DDT	0.0280	B	UG/L	0.2000
OW24-MW02-R01	10/30/98	ACENAPHTHYLENE	570.0000		UG/L	110.0000
OW24-MW02-R01	10/30/98	ALPHA-BHC	0.0460	J	UG/L	0.1000
OW24-MW02-R01	10/30/98	ALUMINUM	5130.0000		UG/L	40.8000
OW24-MW02-R01	10/30/98	ANTHRACENE	49.0000		UG/L	11.0000
OW24-MW02-R01	10/30/98	ARSENIC	4.8000	J	UG/L	3.0000
OW24-MW02-R01	10/30/98	BARIUM	96.0000	J	UG/L	0.4000
OW24-MW02-R01	10/30/98	BERYLLIUM	0.7100	B	UG/L	0.2000
OW24-MW02-R01	10/30/98	CADMIUM	0.5800	B	UG/L	0.4000
OW24-MW02-R01	10/30/98	CALCIUM	38200.0000		UG/L	28.0000
OW24-MW02-R01	10/30/98	CHROMIUM	15.1000	B	UG/L	0.7000
OW24-MW02-R01	10/30/98	CIS-1,2-DICHLOROETHENE	0.2000	J	UG/L	1.0000
OW24-MW02-R01	10/30/98	COBALT	3.3000	J	UG/L	0.6000
OW24-MW02-R01	10/30/98	COPPER	14.1000	B	UG/L	0.6000
OW24-MW02-R01	10/30/98	IRON	4590.0000		UG/L	23.5000
OW24-MW02-R01	10/30/98	LEAD	15.5000		UG/L	1.7000
OW24-MW02-R01	10/30/98	MAGNESIUM	4650.0000	J	UG/L	24.2000
OW24-MW02-R01	10/30/98	MANGANESE	66.6000		UG/L	1.1000
OW24-MW02-R01	10/30/98	MERCURY	0.1000	J	UG/L	0.1000
OW24-MW02-R01	10/30/98	METHYLENE CHLORIDE	0.5000	B	UG/L	2.0000
OW24-MW02-R01	10/30/98	NICKEL	24.6000	B	UG/L	1.3000
OW24-MW02-R01	10/30/98	POTASSIUM	7260.0000		UG/L	20.2000
OW24-MW02-R01	10/30/98	SODIUM	9980.0000		UG/L	210.0000
OW24-MW02-R01	10/30/98	THALLIUM	5.6000	B	UG/L	4.1000
OW24-MW02-R01	10/30/98	VANADIUM	14.7000	J	UG/L	0.8000
OW24-MW02-R01	10/30/98	ZINC	135.0000	B	UG/L	2.0000

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW03F-R01	11/04/98	ALUMINUM	323.0000		UG/L	40.8000
OW24-MW03F-R01	11/04/98	BARIUM	125.0000	J	UG/L	0.4000
OW24-MW03F-R01	11/04/98	BERYLLIUM	1.3000	J	UG/L	0.2000
OW24-MW03F-R01	11/04/98	CALCIUM	13300.0000		UG/L	28.0000
OW24-MW03F-R01	11/04/98	COBALT	5.3000	J	UG/L	0.6000
OW24-MW03F-R01	11/04/98	COPPER	15.7000	B	UG/L	0.6000
OW24-MW03F-R01	11/04/98	IRON	2520.0000		UG/L	23.5000
OW24-MW03F-R01	11/04/98	MAGNESIUM	4980.0000	J	UG/L	24.2000
OW24-MW03F-R01	11/04/98	MANGANESE	47.4000		UG/L	1.1000
OW24-MW03F-R01	11/04/98	NICKEL	8.1000	J	UG/L	1.3000
OW24-MW03F-R01	11/04/98	POTASSIUM	1430.0000	J	UG/L	20.2000
OW24-MW03F-R01	11/04/98	SELENIUM	4.1000	B	UG/L	1.9000
OW24-MW03F-R01	11/04/98	SODIUM	10200.0000	B	UG/L	210.0000
OW24-MW03F-R01	11/04/98	ZINC	43.5000	B	UG/L	2.0000
OW24-MW03-R01	11/04/98	4,4'-DDD	0.0480	B	UG/L	0.1100
OW24-MW03-R01	11/04/98	4,4'-DDT	0.0460	B	UG/L	0.1100
OW24-MW03-R01	11/04/98	ALUMINUM	1320.0000		UG/L	40.8000
OW24-MW03-R01	11/04/98	ARSENIC	5.7000	J	UG/L	3.0000
OW24-MW03-R01	11/04/98	BARIUM	154.0000	J	UG/L	0.4000
OW24-MW03-R01	11/04/98	BENZENE	0.7000	J	UG/L	1.0000
OW24-MW03-R01	11/04/98	BERYLLIUM	1.8000	J	UG/L	0.2000
OW24-MW03-R01	11/04/98	BIS-(2-ETHYLHEXYL)PHTHALATE	1.0000	J	UG/L	11.0000
OW24-MW03-R01	11/04/98	CADMIUM	0.4400	B	UG/L	0.4000
OW24-MW03-R01	11/04/98	CALCIUM	14300.0000		UG/L	28.0000
OW24-MW03-R01	11/04/98	CARBON DISULFIDE	0.2000	J	UG/L	1.0000
OW24-MW03-R01	11/04/98	CHROMIUM	4.0000	B	UG/L	0.7000
OW24-MW03-R01	11/04/98	CIS-1,2-DICHLOROETHENE	72.6000		UG/L	5.0000
OW24-MW03-R01	11/04/98	COBALT	6.4000	J	UG/L	0.6000
OW24-MW03-R01	11/04/98	COPPER	7.1000	B	UG/L	0.6000
OW24-MW03-R01	11/04/98	CYANIDE	22.6000	B	UG/L	5.0000
OW24-MW03-R01	11/04/98	IRON	3980.0000		UG/L	23.5000
OW24-MW03-R01	11/04/98	LEAD	3.1000		UG/L	1.7000
OW24-MW03-R01	11/04/98	MAGNESIUM	5430.0000		UG/L	24.2000
OW24-MW03-R01	11/04/98	MANGANESE	50.1000		UG/L	1.1000
OW24-MW03-R01	11/04/98	METHYLENE CHLORIDE	1.1000	B	UG/L	2.0000
OW24-MW03-R01	11/04/98	NICKEL	8.0000	J	UG/L	1.3000
OW24-MW03-R01	11/04/98	POTASSIUM	1560.0000	J	UG/L	20.2000
OW24-MW03-R01	11/04/98	SODIUM	10200.0000	B	UG/L	210.0000
OW24-MW03-R01	11/04/98	TRANS-1,2-DICHLOROETHENE	3.8000		UG/L	1.0000
OW24-MW03-R01	11/04/98	TRICHLOROETHENE	5.6000		UG/L	1.0000
OW24-MW03-R01	11/04/98	VANADIUM	4.3000	L	UG/L	0.8000
OW24-MW03-R01	11/04/98	VINYL CHLORIDE	0.3000	J	UG/L	1.0000
OW24-MW03-R01	11/04/98	ZINC	38.3000	B	UG/L	2.0000
OW24-MW04-R01	10/28/98	4,4'-DDT	0.03	B	UG/L	0.11
OW24-MW04-R01	10/28/98	ALUMINUM	2680.00		UG/L	40.80
OW24-MW04-R01	10/28/98	ARSENIC	24.30		UG/L	3.00
OW24-MW04-R01	10/28/98	ARSENIC	40.90		UG/L	3.00
OW24-MW04-R01	10/28/98	BARIUM	27.10	J	UG/L	0.40
OW24-MW04-R01	10/28/98	BARIUM	40.90	J	UG/L	0.40
OW24-MW04-R01	10/28/98	BERYLLIUM	0.27	J	UG/L	0.20
OW24-MW04-R01	10/28/98	CALCIUM	5270.00		UG/L	28.00
OW24-MW04-R01	10/28/98	CALCIUM	5310.00		UG/L	28.00
OW24-MW04-R01	10/28/98	CARBON DISULFIDE	1.60	B	UG/L	1.00
OW24-MW04-R01	10/28/98	CHROMIUM	4.90	J	UG/L	0.70
OW24-MW04-R01	10/28/98	CHROMIUM	10.00		UG/L	0.70
OW24-MW04-R01	10/28/98	COBALT	1.50	B	UG/L	0.60
OW24-MW04-R01	10/28/98	COBALT	2.40	B	UG/L	0.60
OW24-MW04-R01	10/28/98	COPPER	4.50	B	UG/L	0.60
OW24-MW04-R01	10/28/98	COPPER	6.50	B	UG/L	0.60
OW24-MW04-R01	10/28/98	IRON	23100.00		UG/L	23.50
OW24-MW04-R01	10/28/98	IRON	29000.00		UG/L	23.50
OW24-MW04-R01	10/28/98	LEAD	1.70	J	UG/L	1.70

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW04-R01	10/28/98	MAGNESIUM	4680.00	J	UG/L	24.20
OW24-MW04-R01	10/28/98	MAGNESIUM	4730.00	J	UG/L	24.20
OW24-MW04-R01	10/28/98	MANGANESE	91.20		UG/L	1.10
OW24-MW04-R01	10/28/98	MANGANESE	95.80		UG/L	1.10
OW24-MW04-R01	10/28/98	METHYLENE CHLORIDE	0.50	B	UG/L	2.00
OW24-MW04-R01	10/28/98	NICKEL	7.90	L	UG/L	1.30
OW24-MW04-R01	10/28/98	NICKEL	9.60	J	UG/L	1.30
OW24-MW04-R01	10/28/98	POTASSIUM	762.00	J	UG/L	20.20
OW24-MW04-R01	10/28/98	POTASSIUM	1220.00	J	UG/L	20.20
OW24-MW04-R01	10/28/98	SELENIUM	2.80	B	UG/L	1.90
OW24-MW04-R01	10/28/98	SELENIUM	3.60	B	UG/L	1.90
OW24-MW04-R01	10/28/98	SODIUM	11000.00		UG/L	210.00
OW24-MW04-R01	10/28/98	SODIUM	11700.00		UG/L	210.00
OW24-MW04-R01	10/28/98	VANADIUM	0.96	B	UG/L	0.80
OW24-MW04-R01	10/28/98	VANADIUM	5.80	J	UG/L	0.80
OW24-MW04-R01	10/28/98	ZINC	17.60	B	UG/L	2.00
OW24-MW04-R01	10/28/98	ZINC	20.50	B	UG/L	2.00
OW24-MW05-R01	10/27/98	4,4'-DDT	0.03	B	UG/L	0.11
OW24-MW05-R01	10/27/98	ALUMINUM	1450.00		UG/L	40.80
OW24-MW05-R01	10/27/98	ARSENIC	8.40	B	UG/L	3.00
OW24-MW05-R01	10/27/98	ARSENIC	14.80	B	UG/L	3.00
OW24-MW05-R01	10/27/98	BARIUM	21.80	J	UG/L	0.40
OW24-MW05-R01	10/27/98	BARIUM	28.70	J	UG/L	0.40
OW24-MW05-R01	10/27/98	BENZO(A)ANTHRACENE	0.00	B	UG/L	0.01
OW24-MW05-R01	10/27/98	CALCIUM	7320.00		UG/L	28.00
OW24-MW05-R01	10/27/98	CALCIUM	7750.00		UG/L	28.00
OW24-MW05-R01	10/27/98	CHROMIUM	4.00	J	UG/L	0.70
OW24-MW05-R01	10/27/98	CHRYSENE	0.00	B	UG/L	0.01
OW24-MW05-R01	10/27/98	COBALT	1.90	B	UG/L	0.60
OW24-MW05-R01	10/27/98	COBALT	1.90	B	UG/L	0.60
OW24-MW05-R01	10/27/98	COPPER	1.80	B	UG/L	0.60
OW24-MW05-R01	10/27/98	COPPER	15.90	B	UG/L	0.60
OW24-MW05-R01	10/27/98	IRON	10300.00		UG/L	23.50
OW24-MW05-R01	10/27/98	IRON	12800.00		UG/L	23.50
OW24-MW05-R01	10/27/98	MAGNESIUM	7040.00		UG/L	24.20
OW24-MW05-R01	10/27/98	MAGNESIUM	7650.00		UG/L	24.20
OW24-MW05-R01	10/27/98	MANGANESE	270.00		UG/L	1.10
OW24-MW05-R01	10/27/98	MANGANESE	319.00		UG/L	1.10
OW24-MW05-R01	10/27/98	NICKEL	2.20	L	UG/L	1.30
OW24-MW05-R01	10/27/98	POTASSIUM	1010.00	J	UG/L	20.20
OW24-MW05-R01	10/27/98	POTASSIUM	1230.00	J	UG/L	20.20
OW24-MW05-R01	10/27/98	PYRENE	0.00	B	UG/L	0.01
OW24-MW05-R01	10/27/98	SELENIUM	3.40	B	UG/L	1.90
OW24-MW05-R01	10/27/98	SODIUM	10700.00		UG/L	210.00
OW24-MW05-R01	10/27/98	SODIUM	11100.00		UG/L	210.00
OW24-MW05-R01	10/27/98	VANADIUM	1.40	B	UG/L	0.80
OW24-MW05-R01	10/27/98	VANADIUM	3.40	B	UG/L	0.80
OW24-MW05-R01	10/27/98	ZINC	25.90	B	UG/L	2.00
OW24-MW05-R01	10/27/98	ZINC	33.30	B	UG/L	2.00
OW24-MW06-R01	10/27/98	4,4'-DDT	0.01	B	UG/L	0.11
OW24-MW06-R01	10/27/98	ALUMINUM	41.70	B	UG/L	40.80
OW24-MW06-R01	10/27/98	ALUMINUM	392.00		UG/L	40.80
OW24-MW06-R01	10/27/98	ARSENIC	9.30	B	UG/L	3.00
OW24-MW06-R01	10/27/98	ARSENIC	12.90	B	UG/L	3.00
OW24-MW06-R01	10/27/98	BARIUM	25.60	J	UG/L	0.40
OW24-MW06-R01	10/27/98	BARIUM	27.30	J	UG/L	0.40
OW24-MW06-R01	10/27/98	BENZO(A)ANTHRACENE	0.00	B	UG/L	0.01
OW24-MW06-R01	10/27/98	CALCIUM	6580.00		UG/L	28.00
OW24-MW06-R01	10/27/98	CALCIUM	6580.00		UG/L	28.00
OW24-MW06-R01	10/27/98	CHROMIUM	0.98	J	UG/L	0.70
OW24-MW06-R01	10/27/98	CHROMIUM	1.80	J	UG/L	0.70
OW24-MW06-R01	10/27/98	CHRYSENE	0.00	B	UG/L	0.01

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW06-R01	10/27/98	COBALT	17.40	J	UG/L	0.60
OW24-MW06-R01	10/27/98	COBALT	19.50	J	UG/L	0.60
OW24-MW06-R01	10/27/98	COPPER	1.90	B	UG/L	0.60
OW24-MW06-R01	10/27/98	COPPER	4.70	B	UG/L	0.60
OW24-MW06-R01	10/27/98	CYANIDE	5.70	J	UG/L	5.00
OW24-MW06-R01	10/27/98	IRON	30300.00		UG/L	23.50
OW24-MW06-R01	10/27/98	IRON	32900.00		UG/L	23.50
OW24-MW06-R01	10/27/98	MAGNESIUM	4610.00	J	UG/L	24.20
OW24-MW06-R01	10/27/98	MAGNESIUM	4670.00	J	UG/L	24.20
OW24-MW06-R01	10/27/98	MANGANESE	499.00		UG/L	1.10
OW24-MW06-R01	10/27/98	MANGANESE	538.00		UG/L	1.10
OW24-MW06-R01	10/27/98	NICKEL	2.30	L	UG/L	1.30
OW24-MW06-R01	10/27/98	NICKEL	2.40	L	UG/L	1.30
OW24-MW06-R01	10/27/98	POTASSIUM	574.00	J	UG/L	20.20
OW24-MW06-R01	10/27/98	POTASSIUM	610.00	J	UG/L	20.20
OW24-MW06-R01	10/27/98	PYRENE	0.00	B	UG/L	0.01
OW24-MW06-R01	10/27/98	SELENIUM	2.70	B	UG/L	1.90
OW24-MW06-R01	10/27/98	SODIUM	12200.00		UG/L	210.00
OW24-MW06-R01	10/27/98	SODIUM	12400.00		UG/L	210.00
OW24-MW06-R01	10/27/98	VANADIUM	1.20	B	UG/L	0.80
OW24-MW06-R01	10/27/98	ZINC	19.40	B	UG/L	2.00
OW24-MW06-R01	10/27/98	ZINC	30.50	B	UG/L	2.00
OW24-MW10F-R01	11/6/98	ALUMINUM	100.0000	B	UG/L	40.8000
OW24-MW10F-R01	11/6/98	ARSENIC	20.2000		UG/L	3.0000
OW24-MW10F-R01	11/6/98	BARIUM	24.4000	J	UG/L	0.4000
OW24-MW10F-R01	11/6/98	CALCIUM	5330.0000		UG/L	28.0000
OW24-MW10F-R01	11/6/98	CHROMIUM	1.3000	B	UG/L	0.7000
OW24-MW10F-R01	11/6/98	COBALT	10.1000	J	UG/L	0.6000
OW24-MW10F-R01	11/6/98	COPPER	2.6000	B	UG/L	0.6000
OW24-MW10F-R01	11/6/98	IRON	15100.0000		UG/L	23.5000
OW24-MW10F-R01	11/6/98	MAGNESIUM	4170.0000	J	UG/L	24.2000
OW24-MW10F-R01	11/6/98	MANGANESE	743.0000		UG/L	1.1000
OW24-MW10F-R01	11/6/98	NICKEL	2.8000	B	UG/L	1.3000
OW24-MW10F-R01	11/6/98	POTASSIUM	1050.0000	J	UG/L	20.2000
OW24-MW10F-R01	11/6/98	SODIUM	6900.0000		UG/L	210.0000
OW24-MW10F-R01	11/6/98	ZINC	15.9000	B	UG/L	2.0000
OW24-MW10-R01	11/6/98	4,4'-DDD	0.0440	J	UG/L	0.1000
OW24-MW10-R01	11/6/98	4,4'-DDT	0.0110	B	UG/L	0.1000
OW24-MW10-R01	11/6/98	ACENAPHTHENE	0.0670	K	UG/L	0.2200
OW24-MW10-R01	11/6/98	ALUMINUM	354.0000		UG/L	40.8000
OW24-MW10-R01	11/6/98	ANTHRACENE	0.0790	B	UG/L	0.1100
OW24-MW10-R01	11/6/98	ARSENIC	20.3000		UG/L	3.0000
OW24-MW10-R01	11/6/98	BARIUM	28.3000	B	UG/L	0.4000
OW24-MW10-R01	11/6/98	CALCIUM	5410.0000		UG/L	28.0000
OW24-MW10-R01	11/6/98	CARBON DISULFIDE	0.4000	J	UG/L	1.0000
OW24-MW10-R01	11/6/98	CHROMIUM	1.3000	B	UG/L	0.7000
OW24-MW10-R01	11/6/98	COBALT	10.6000	J	UG/L	0.6000
OW24-MW10-R01	11/6/98	COPPER	3.9000	B	UG/L	0.6000
OW24-MW10-R01	11/6/98	CYANIDE	43.0000	B	UG/L	5.0000
OW24-MW10-R01	11/6/98	FLUORANTHENE	0.3700	K	UG/L	1.1000
OW24-MW10-R01	11/6/98	FLUORENE	0.1600	K	UG/L	0.4500
OW24-MW10-R01	11/6/98	IRON	15600.0000		UG/L	23.5000
OW24-MW10-R01	11/6/98	MAGNESIUM	4270.0000	J	UG/L	24.2000
OW24-MW10-R01	11/6/98	MANGANESE	763.0000		UG/L	1.1000
OW24-MW10-R01	11/6/98	METHYLENE CHLORIDE	0.2000	B	UG/L	2.0000
OW24-MW10-R01	11/6/98	NAPHTHALENE	0.2900	B	UG/L	2.2000
OW24-MW10-R01	11/6/98	NICKEL	3.0000	B	UG/L	1.3000
OW24-MW10-R01	11/6/98	PHENANTHRENE	0.0220	B	UG/L	0.0560
OW24-MW10-R01	11/6/98	POTASSIUM	1090.0000	J	UG/L	20.2000
OW24-MW10-R01	11/6/98	PYRENE	0.0030	B	UG/L	0.0060
OW24-MW10-R01	11/6/98	SODIUM	6890.0000		UG/L	210.0000
OW24-MW10-R01	11/6/98	VANADIUM	2.2000	B	UG/L	0.8000

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW10-R01	11/6/98	ZINC	23.0000	B	UG/L	2.0000
OW24-MW11F-R01	11/04/98	ALUMINUM	229.0000	B	UG/L	40.8000
OW24-MW11F-R01	11/04/98	ARSENIC	4.8000	J	UG/L	3.0000
OW24-MW11F-R01	11/04/98	BARIUM	10.3000	J	UG/L	0.4000
OW24-MW11F-R01	11/04/98	BERYLLIUM	0.3400	J	UG/L	0.2000
OW24-MW11F-R01	11/04/98	CALCIUM	3450.0000	J	UG/L	28.0000
OW24-MW11F-R01	11/04/98	CHROMIUM	5.2000	B	UG/L	0.7000
OW24-MW11F-R01	11/04/98	COBALT	0.7800	J	UG/L	0.6000
OW24-MW11F-R01	11/04/98	COPPER	4.7000	B	UG/L	0.6000
OW24-MW11F-R01	11/04/98	IRON	3900.0000		UG/L	23.5000
OW24-MW11F-R01	11/04/98	MAGNESIUM	2880.0000	J	UG/L	24.2000
OW24-MW11F-R01	11/04/98	MANGANESE	62.0000		UG/L	1.1000
OW24-MW11F-R01	11/04/98	NICKEL	20.9000	J	UG/L	1.3000
OW24-MW11F-R01	11/04/98	POTASSIUM	724.0000	B	UG/L	20.2000
OW24-MW11F-R01	11/04/98	SELENIUM	3.4000	B	UG/L	1.9000
OW24-MW11F-R01	11/04/98	SODIUM	5260.0000	B	UG/L	210.0000
OW24-MW11F-R01	11/04/98	ZINC	27.8000	B	UG/L	2.0000
OW24-MW11PF-RC	11/04/98	ALUMINUM	252.0000	B	UG/L	40.8000
OW24-MW11PF-RC	11/04/98	ARSENIC	8.4000	J	UG/L	3.0000
OW24-MW11PF-RC	11/04/98	BARIUM	10.0000	J	UG/L	0.4000
OW24-MW11PF-RC	11/04/98	BERYLLIUM	0.3900	J	UG/L	0.2000
OW24-MW11PF-RC	11/04/98	CADMIUM	0.5100	B	UG/L	0.4000
OW24-MW11PF-RC	11/04/98	CALCIUM	3430.0000	J	UG/L	28.0000
OW24-MW11PF-RC	11/04/98	CHROMIUM	4.6000	B	UG/L	0.7000
OW24-MW11PF-RC	11/04/98	COBALT	1.2000	J	UG/L	0.6000
OW24-MW11PF-RC	11/04/98	COPPER	3.2000	B	UG/L	0.6000
OW24-MW11PF-RC	11/04/98	IRON	3960.0000		UG/L	23.5000
OW24-MW11PF-RC	11/04/98	MAGNESIUM	2860.0000	J	UG/L	24.2000
OW24-MW11PF-RC	11/04/98	MANGANESE	63.3000		UG/L	1.1000
OW24-MW11PF-RC	11/04/98	NICKEL	23.8000	J	UG/L	1.3000
OW24-MW11PF-RC	11/04/98	POTASSIUM	690.0000	B	UG/L	20.2000
OW24-MW11PF-RC	11/04/98	SODIUM	5170.0000	B	UG/L	210.0000
OW24-MW11PF-RC	11/04/98	ZINC	29.2000	B	UG/L	2.0000
OW24-MW11P-R01	11/04/98	ALUMINUM	461.0000		UG/L	40.8000
OW24-MW11P-R01	11/04/98	ARSENIC	8.6000	J	UG/L	3.0000
OW24-MW11P-R01	11/04/98	BARIUM	9.8000	J	UG/L	0.4000
OW24-MW11P-R01	11/04/98	BERYLLIUM	0.4000	J	UG/L	0.2000
OW24-MW11P-R01	11/04/98	BIS-(2-ETHYLHEXYL)PHTHALATE	1.0000	J	UG/L	11.0000
OW24-MW11P-R01	11/04/98	CALCIUM	3080.0000	J	UG/L	28.0000
OW24-MW11P-R01	11/04/98	CHROMIUM	1.3000	B	UG/L	0.7000
OW24-MW11P-R01	11/04/98	COBALT	0.7900	J	UG/L	0.6000
OW24-MW11P-R01	11/04/98	COPPER	2.9000	B	UG/L	0.6000
OW24-MW11P-R01	11/04/98	CYANIDE	17.8000	B	UG/L	5.0000
OW24-MW11P-R01	11/04/98	DI-N-BUTYLPHTHALATE	1.0000	J	UG/L	11.0000
OW24-MW11P-R01	11/04/98	IRON	4170.0000		UG/L	23.5000
OW24-MW11P-R01	11/04/98	MAGNESIUM	2790.0000	J	UG/L	24.2000
OW24-MW11P-R01	11/04/98	MANGANESE	57.4000		UG/L	1.1000
OW24-MW11P-R01	11/04/98	METHYLENE CHLORIDE	0.8000	B	UG/L	2.0000
OW24-MW11P-R01	11/04/98	NICKEL	2.4000	J	UG/L	1.3000
OW24-MW11P-R01	11/04/98	POTASSIUM	710.0000	B	UG/L	20.2000
OW24-MW11P-R01	11/04/98	SELENIUM	2.0000	B	UG/L	1.9000
OW24-MW11P-R01	11/04/98	SODIUM	5110.0000	B	UG/L	210.0000
OW24-MW11P-R01	11/04/98	VANADIUM	0.8400	L	UG/L	0.8000
OW24-MW11P-R01	11/04/98	ZINC	26.4000	B	UG/L	2.0000
OW24-MW11-R01	11/04/98	4,4'-DDD	0.0590	B	UG/L	0.1100
OW24-MW11-R01	11/04/98	4,4'-DDT	0.0130	B	UG/L	0.1100
OW24-MW11-R01	11/04/98	ALUMINUM	1020.0000		UG/L	40.8000
OW24-MW11-R01	11/04/98	ARSENIC	8.1000	J	UG/L	3.0000
OW24-MW11-R01	11/04/98	BARIUM	11.8000	J	UG/L	0.4000
OW24-MW11-R01	11/04/98	BERYLLIUM	0.4100	J	UG/L	0.2000
OW24-MW11-R01	11/04/98	CALCIUM	3130.0000	J	UG/L	28.0000
OW24-MW11-R01	11/04/98	CHROMIUM	2.6000	B	UG/L	0.7000

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OW24-MW11-R01	11/04/98	COBALT	0.8900	J	UG/L	0.6000
OW24-MW11-R01	11/04/98	COPPER	2.8000	B	UG/L	0.6000
OW24-MW11-R01	11/04/98	CYANIDE	56.7000	B	UG/L	5.0000
OW24-MW11-R01	11/04/98	IRON	4470.0000		UG/L	23.5000
OW24-MW11-R01	11/04/98	MAGNESIUM	2860.0000	J	UG/L	24.2000
OW24-MW11-R01	11/04/98	MANGANESE	59.2000		UG/L	1.1000
OW24-MW11-R01	11/04/98	METHYLENE CHLORIDE	1.0000	B	UG/L	2.0000
OW24-MW11-R01	11/04/98	NICKEL	4.7000	J	UG/L	1.3000
OW24-MW11-R01	11/04/98	POTASSIUM	849.0000	J	UG/L	20.2000
OW24-MW11-R01	11/04/98	SODIUM	5150.0000	B	UG/L	210.0000
OW24-MW11-R01	11/04/98	VANADIUM	1.6000	L	UG/L	0.8000
OW24-MW11-R01	11/04/98	ZINC	23.1000	B	UG/L	2.0000
OW24-MW1DF-R01	11/04/98	BARIUM	19.8000	J	UG/L	0.4000
OW24-MW1DF-R01	11/04/98	CALCIUM	79000.0000		UG/L	28.0000
OW24-MW1DF-R01	11/04/98	COPPER	2.5000	B	UG/L	0.6000
OW24-MW1DF-R01	11/04/98	IRON	2450.0000		UG/L	23.5000
OW24-MW1DF-R01	11/04/98	MAGNESIUM	9890.0000		UG/L	24.2000
OW24-MW1DF-R01	11/04/98	MANGANESE	199.0000		UG/L	1.1000
OW24-MW1DF-R01	11/04/98	POTASSIUM	3310.0000	J	UG/L	20.2000
OW24-MW1DF-R01	11/04/98	SELENIUM	3.0000	B	UG/L	1.9000
OW24-MW1DF-R01	11/04/98	SODIUM	25000.0000		UG/L	210.0000
OW24-MW1DF-R01	11/04/98	ZINC	14.0000	B	UG/L	2.0000
OW24-MW1D-R01	11/04/98	4,4'-DDD	0.0500	B	UG/L	0.1100
OW24-MW1D-R01	11/04/98	4,4'-DDT	0.0140	B	UG/L	0.1100
OW24-MW1D-R01	11/04/98	ALUMINUM	930.0000		UG/L	40.8000
OW24-MW1D-R01	11/04/98	ANTHRACENE	0.4900		UG/L	0.1100
OW24-MW1D-R01	11/04/98	BARIUM	24.1000	J	UG/L	0.4000
OW24-MW1D-R01	11/04/98	BENZO(A)ANTHRACENE	0.0260	B	UG/L	0.0110
OW24-MW1D-R01	11/04/98	BIS-(2-ETHYLHEXYL)PHTHALATE	1.0000	J	UG/L	11.0000
OW24-MW1D-R01	11/04/98	CALCIUM	80100.0000		UG/L	28.0000
OW24-MW1D-R01	11/04/98	CHROMIUM	4.0000	B	UG/L	0.7000
OW24-MW1D-R01	11/04/98	CIS-1,2-DICHLOROETHENE	0.4000	J	UG/L	1.0000
OW24-MW1D-R01	11/04/98	COBALT	0.8200	J	UG/L	0.6000
OW24-MW1D-R01	11/04/98	COPPER	3.6000	B	UG/L	0.6000
OW24-MW1D-R01	11/04/98	CYANIDE	27.7000	B	UG/L	5.0000
OW24-MW1D-R01	11/04/98	IRON	3910.0000		UG/L	23.5000
OW24-MW1D-R01	11/04/98	MAGNESIUM	10300.0000		UG/L	24.2000
OW24-MW1D-R01	11/04/98	MANGANESE	219.0000		UG/L	1.1000
OW24-MW1D-R01	11/04/98	METHYLENE CHLORIDE	0.9000	B	UG/L	2.0000
OW24-MW1D-R01	11/04/98	NICKEL	2.9000	J	UG/L	1.3000
OW24-MW1D-R01	11/04/98	PHENANTHRENE	0.0670		UG/L	0.0540
OW24-MW1D-R01	11/04/98	POTASSIUM	3540.0000	J	UG/L	20.2000
OW24-MW1D-R01	11/04/98	SELENIUM	2.7000	B	UG/L	1.9000
OW24-MW1D-R01	11/04/98	SODIUM	25300.0000		UG/L	210.0000
OW24-MW1D-R01	11/04/98	VANADIUM	3.6000	L	UG/L	0.8000
OW24-MW1D-R01	11/04/98	ZINC	18.5000	B	UG/L	2.0000
OW24-MW7F-R01	11/6/98	ALUMINUM	99.5000	B	UG/L	40.8000
OW24-MW7F-R01	11/6/98	ARSENIC	14.8000		UG/L	3.0000
OW24-MW7F-R01	11/6/98	BARIUM	15.5000	B	UG/L	0.4000
OW24-MW7F-R01	11/6/98	CALCIUM	8560.0000		UG/L	28.0000
OW24-MW7F-R01	11/6/98	CHROMIUM	2.2000	B	UG/L	0.7000
OW24-MW7F-R01	11/6/98	COBALT	2.4000	B	UG/L	0.6000
OW24-MW7F-R01	11/6/98	COPPER	3.6000	B	UG/L	0.6000
OW24-MW7F-R01	11/6/98	IRON	9090.0000		UG/L	23.5000
OW24-MW7F-R01	11/6/98	MAGNESIUM	3720.0000	J	UG/L	24.2000
OW24-MW7F-R01	11/6/98	MANGANESE	90.9000		UG/L	1.1000
OW24-MW7F-R01	11/6/98	NICKEL	6.1000	B	UG/L	1.3000
OW24-MW7F-R01	11/6/98	POTASSIUM	650.0000	J	UG/L	20.2000
OW24-MW7F-R01	11/6/98	SODIUM	8300.0000		UG/L	210.0000
OW24-MW7F-R01	11/6/98	ZINC	21.8000	B	UG/L	2.0000
OW24-MW7-R01	11/6/98	4,4'-DDD	0.0320	J	UG/L	0.1100
OW24-MW7-R01	11/6/98	4,4'-DDE	0.0057	J	UG/L	0.1100

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW7-R01	11/6/98	4,4'-DDT	0.0750	B	UG/L	0.1100
OW24-MW7-R01	11/6/98	ALUMINUM	623.0000		UG/L	40.8000
OW24-MW7-R01	11/6/98	ARSENIC	16.8000		UG/L	3.0000
OW24-MW7-R01	11/6/98	BARIUM	18.1000	B	UG/L	0.4000
OW24-MW7-R01	11/6/98	CALCIUM	7630.0000		UG/L	28.0000
OW24-MW7-R01	11/6/98	CHROMIUM	5.3000	B	UG/L	0.7000
OW24-MW7-R01	11/6/98	COBALT	2.6000	B	UG/L	0.6000
OW24-MW7-R01	11/6/98	COPPER	3.8000	B	UG/L	0.6000
OW24-MW7-R01	11/6/98	CYANIDE	17.8000	B	UG/L	5.0000
OW24-MW7-R01	11/6/98	DI-N-BUTYLPHTHALATE	9.0000	J	UG/L	11.0000
OW24-MW7-R01	11/6/98	IRON	9840.0000		UG/L	23.5000
OW24-MW7-R01	11/6/98	MAGNESIUM	3530.0000	J	UG/L	24.2000
OW24-MW7-R01	11/6/98	MANGANESE	80.1000		UG/L	1.1000
OW24-MW7-R01	11/6/98	METHYLENE CHLORIDE	0.2000	B	UG/L	2.0000
OW24-MW7-R01	11/6/98	NAPHTHALENE	0.3600	B	UG/L	2.2000
OW24-MW7-R01	11/6/98	NICKEL	7.8000	B	UG/L	1.3000
OW24-MW7-R01	11/6/98	PHENANTHRENE	0.0570	B	UG/L	0.0540
OW24-MW7-R01	11/6/98	POTASSIUM	700.0000	J	UG/L	20.2000
OW24-MW7-R01	11/6/98	SELENIUM	1.9000	J	UG/L	1.9000
OW24-MW7-R01	11/6/98	SODIUM	7800.0000		UG/L	210.0000
OW24-MW7-R01	11/6/98	VANADIUM	1.5000	B	UG/L	0.8000
OW24-MW7-R01	11/6/98	ZINC	20.9000	B	UG/L	2.0000
OW24-MW8F-R01	11/6/98	ALUMINUM	119.0000	B	UG/L	40.8000
OW24-MW8F-R01	11/6/98	BARIUM	27.6000	J	UG/L	0.4000
OW24-MW8F-R01	11/6/98	BERYLLIUM	0.3000	J	UG/L	0.2000
OW24-MW8F-R01	11/6/98	CALCIUM	5230.0000		UG/L	28.0000
OW24-MW8F-R01	11/6/98	COBALT	15.1000	J	UG/L	0.6000
OW24-MW8F-R01	11/6/98	COPPER	3.1000	B	UG/L	0.6000
OW24-MW8F-R01	11/6/98	IRON	2560.0000		UG/L	23.5000
OW24-MW8F-R01	11/6/98	MAGNESIUM	2920.0000	J	UG/L	24.2000
OW24-MW8F-R01	11/6/98	MANGANESE	66.1000		UG/L	1.1000
OW24-MW8F-R01	11/6/98	NICKEL	17.5000	B	UG/L	1.3000
OW24-MW8F-R01	11/6/98	POTASSIUM	927.0000	J	UG/L	20.2000
OW24-MW8F-R01	11/6/98	SODIUM	3850.0000	J	UG/L	210.0000
OW24-MW8F-R01	11/6/98	ZINC	28.3000	B	UG/L	2.0000
OW24-MW8-R01	11/6/98	ALUMINUM	768.0000		UG/L	40.8000
OW24-MW8-R01	11/6/98	ARSENIC	12.4000		UG/L	3.0000
OW24-MW8-R01	11/6/98	BARIUM	35.8000	J	UG/L	0.4000
OW24-MW8-R01	11/6/98	BERYLLIUM	0.5000	J	UG/L	0.2000
OW24-MW8-R01	11/6/98	CALCIUM	5660.0000		UG/L	28.0000
OW24-MW8-R01	11/6/98	CHROMIUM	1.4000	B	UG/L	0.7000
OW24-MW8-R01	11/6/98	COBALT	16.8000	J	UG/L	0.6000
OW24-MW8-R01	11/6/98	COPPER	3.8000	B	UG/L	0.6000
OW24-MW8-R01	11/6/98	CYANIDE	46.2000	B	UG/L	5.0000
OW24-MW8-R01	11/6/98	IRON	7610.0000		UG/L	23.5000
OW24-MW8-R01	11/6/98	LEAD	2.1000	J	UG/L	1.7000
OW24-MW8-R01	11/6/98	MAGNESIUM	3150.0000	J	UG/L	24.2000
OW24-MW8-R01	11/6/98	MANGANESE	71.2000		UG/L	1.1000
OW24-MW8-R01	11/6/98	METHYLENE CHLORIDE	0.3000	B	UG/L	2.0000
OW24-MW8-R01	11/6/98	NICKEL	18.9000	B	UG/L	1.3000
OW24-MW8-R01	11/6/98	POTASSIUM	930.0000	J	UG/L	20.2000
OW24-MW8-R01	11/6/98	SODIUM	3920.0000	J	UG/L	210.0000
OW24-MW8-R01	11/6/98	VANADIUM	2.8000	B	UG/L	0.8000
OW24-MW8-R01	11/6/98	ZINC	38.4000	B	UG/L	2.0000
OW24-MW9F-R01	11/6/98	ALUMINUM	61.8000	B	UG/L	40.8000
OW24-MW9F-R01	11/6/98	BARIUM	16.2000	B	UG/L	0.4000
OW24-MW9F-R01	11/6/98	CALCIUM	5830.0000		UG/L	28.0000
OW24-MW9F-R01	11/6/98	CHROMIUM	0.9900	B	UG/L	0.7000
OW24-MW9F-R01	11/6/98	COPPER	3.5000	B	UG/L	0.6000
OW24-MW9F-R01	11/6/98	IRON	6180.0000		UG/L	23.5000
OW24-MW9F-R01	11/6/98	MAGNESIUM	4470.0000	J	UG/L	24.2000
OW24-MW9F-R01	11/6/98	MANGANESE	121.0000		UG/L	1.1000

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-MW9F-R01	11/6/98	NICKEL	1.5000	B	UG/L	1.3000
OW24-MW9F-R01	11/6/98	POTASSIUM	949.0000	J	UG/L	20.2000
OW24-MW9F-R01	11/6/98	SODIUM	10600.0000		UG/L	210.0000
OW24-MW9F-R01	11/6/98	ZINC	14.5000	B	UG/L	2.0000
OW24-MW9-R01	11/6/98	ALUMINUM	2070.0000		UG/L	40.8000
OW24-MW9-R01	11/6/98	BARIUM	49.4000	J	UG/L	0.4000
OW24-MW9-R01	11/6/98	BERYLLIUM	0.3200	J	UG/L	0.2000
OW24-MW9-R01	11/6/98	CALCIUM	6010.0000		UG/L	28.0000
OW24-MW9-R01	11/6/98	CARBON DISULFIDE	0.6000	J	UG/L	1.0000
OW24-MW9-R01	11/6/98	CHROMIUM	5.6000	B	UG/L	0.7000
OW24-MW9-R01	11/6/98	CIS-1,2-DICHLOROETHENE	2.2000		UG/L	1.0000
OW24-MW9-R01	11/6/98	COBALT	2.7000	B	UG/L	0.6000
OW24-MW9-R01	11/6/98	COPPER	7.3000	B	UG/L	0.6000
OW24-MW9-R01	11/6/98	CYANIDE	33.6000	B	UG/L	5.0000
OW24-MW9-R01	11/6/98	IRON	8760.0000		UG/L	23.5000
OW24-MW9-R01	11/6/98	LEAD	3.8000		UG/L	1.7000
OW24-MW9-R01	11/6/98	MAGNESIUM	5180.0000		UG/L	24.2000
OW24-MW9-R01	11/6/98	MANGANESE	143.0000		UG/L	1.1000
OW24-MW9-R01	11/6/98	METHYLENE CHLORIDE	0.3000	B	UG/L	2.0000
OW24-MW9-R01	11/6/98	NICKEL	6.6000	B	UG/L	1.3000
OW24-MW9-R01	11/6/98	POTASSIUM	1310.0000	J	UG/L	20.2000
OW24-MW9-R01	11/6/98	SODIUM	9700.0000		UG/L	210.0000
OW24-MW9-R01	11/6/98	TRICHLOROETHENE	8.8000		UG/L	1.0000
OW24-MW9-R01	11/6/98	VANADIUM	10.7000	J	UG/L	0.8000
OW24-MW9-R01	11/6/98	ZINC	32.0000	B	UG/L	2.0000
OW24-PZ3DF-R01	11/04/98	ALUMINUM	50.7000	B	UG/L	40.8000
OW24-PZ3DF-R01	11/04/98	ARSENIC	22.4000		UG/L	3.0000
OW24-PZ3DF-R01	11/04/98	BARIUM	25.3000	J	UG/L	0.4000
OW24-PZ3DF-R01	11/04/98	CALCIUM	6230.0000		UG/L	28.0000
OW24-PZ3DF-R01	11/04/98	COPPER	3.4000	B	UG/L	0.6000
OW24-PZ3DF-R01	11/04/98	IRON	13800.0000		UG/L	23.5000
OW24-PZ3DF-R01	11/04/98	MAGNESIUM	4260.0000	J	UG/L	24.2000
OW24-PZ3DF-R01	11/04/98	MANGANESE	79.6000		UG/L	1.1000
OW24-PZ3DF-R01	11/04/98	NICKEL	1.4000	J	UG/L	1.3000
OW24-PZ3DF-R01	11/04/98	POTASSIUM	2090.0000	J	UG/L	20.2000
OW24-PZ3DF-R01	11/04/98	SELENIUM	2.8000	B	UG/L	1.9000
OW24-PZ3DF-R01	11/04/98	SODIUM	10500.0000	B	UG/L	210.0000
OW24-PZ3DF-R01	11/04/98	VANADIUM	0.9400	L	UG/L	0.8000
OW24-PZ3DF-R01	11/04/98	ZINC	19.4000	B	UG/L	2.0000
OW24-PZ3D-R01	11/04/98	4,4'-DDD	0.0230	B	UG/L	0.1000
OW24-PZ3D-R01	11/04/98	4,4'-DDT	0.0390	B	UG/L	0.1000
OW24-PZ3D-R01	11/04/98	ALUMINUM	906.0000		UG/L	40.8000
OW24-PZ3D-R01	11/04/98	ARSENIC	48.4000		UG/L	3.0000
OW24-PZ3D-R01	11/04/98	BARIUM	38.4000	J	UG/L	0.4000
OW24-PZ3D-R01	11/04/98	BENZENE	0.1000	J	UG/L	1.0000
OW24-PZ3D-R01	11/04/98	BERYLLIUM	0.2500	J	UG/L	0.2000
OW24-PZ3D-R01	11/04/98	CALCIUM	6550.0000		UG/L	28.0000
OW24-PZ3D-R01	11/04/98	CHROMIUM	3.0000	B	UG/L	0.7000
OW24-PZ3D-R01	11/04/98	CIS-1,2-DICHLOROETHENE	39.1000		UG/L	2.0000
OW24-PZ3D-R01	11/04/98	COBALT	1.0000	J	UG/L	0.6000
OW24-PZ3D-R01	11/04/98	COPPER	6.6000	B	UG/L	0.6000
OW24-PZ3D-R01	11/04/98	CYANIDE	23.9000	B	UG/L	5.0000
OW24-PZ3D-R01	11/04/98	ENDRIN KETONE	0.0030	B	UG/L	0.1000
OW24-PZ3D-R01	11/04/98	IRON	20800.0000		UG/L	23.5000
OW24-PZ3D-R01	11/04/98	LEAD	2.5000	J	UG/L	1.7000
OW24-PZ3D-R01	11/04/98	MAGNESIUM	4590.0000	J	UG/L	24.2000
OW24-PZ3D-R01	11/04/98	MANGANESE	91.1000		UG/L	1.1000
OW24-PZ3D-R01	11/04/98	METHYLENE CHLORIDE	0.5000	B	UG/L	2.0000
OW24-PZ3D-R01	11/04/98	NICKEL	3.5000	J	UG/L	1.3000
OW24-PZ3D-R01	11/04/98	POTASSIUM	2080.0000	J	UG/L	20.2000
OW24-PZ3D-R01	11/04/98	SELENIUM	4.8000	B	UG/L	1.9000
OW24-PZ3D-R01	11/04/98	SODIUM	10200.0000	B	UG/L	210.0000

SAMPLE_ID	DATE_COLLECTED	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM
OW24-PZ3D-R01	11/04/98	TRANS-1,2-DICHLOROETHENE	4.5000		UG/L	1.0000
OW24-PZ3D-R01	11/04/98	TRICHLOROETHENE	1.9000		UG/L	1.0000
OW24-PZ3D-R01	11/04/98	VANADIUM	6.2000	L	UG/L	0.8000
OW24-PZ3D-R01	11/04/98	ZINC	43.0000	B	UG/L	2.0000
OW24-PZ3SF-R01	11/04/98	ARSENIC	224.0000		UG/L	3.0000
OW24-PZ3SF-R01	11/04/98	BARIUM	37.2000	J	UG/L	0.4000
OW24-PZ3SF-R01	11/04/98	CALCIUM	15200.0000		UG/L	28.0000
OW24-PZ3SF-R01	11/04/98	CHROMIUM	1.4000	B	UG/L	0.7000
OW24-PZ3SF-R01	11/04/98	COBALT	1.1000	J	UG/L	0.6000
OW24-PZ3SF-R01	11/04/98	COPPER	2.8000	B	UG/L	0.6000
OW24-PZ3SF-R01	11/04/98	IRON	69300.0000		UG/L	23.5000
OW24-PZ3SF-R01	11/04/98	MAGNESIUM	5580.0000		UG/L	24.2000
OW24-PZ3SF-R01	11/04/98	MANGANESE	70.9000		UG/L	1.1000
OW24-PZ3SF-R01	11/04/98	NICKEL	5.7000	J	UG/L	1.3000
OW24-PZ3SF-R01	11/04/98	POTASSIUM	1120.0000	J	UG/L	20.2000
OW24-PZ3SF-R01	11/04/98	SELENIUM	5.9000	B	UG/L	1.9000
OW24-PZ3SF-R01	11/04/98	SODIUM	8820.0000	B	UG/L	210.0000
OW24-PZ3SF-R01	11/04/98	VANADIUM	1.5000	L	UG/L	0.8000
OW24-PZ3SF-R01	11/04/98	ZINC	19.6000	B	UG/L	2.0000
OW24-PZ3S-R01	11/04/98	1,1-DICHLOROETHENE	0.2000	J	UG/L	1.0000
OW24-PZ3S-R01	11/04/98	4,4'-DDD	0.0220	L	UG/L	0.1000
OW24-PZ3S-R01	11/04/98	4,4'-DDT	0.0150	B	UG/L	0.1000
OW24-PZ3S-R01	11/04/98	ACENAPHTHENE	0.7700	K	UG/L	0.2200
OW24-PZ3S-R01	11/04/98	ALUMINUM	3920.0000		UG/L	40.8000
OW24-PZ3S-R01	11/04/98	ANTHRACENE	0.3400	K	UG/L	0.1100
OW24-PZ3S-R01	11/04/98	ARSENIC	222.0000		UG/L	3.0000
OW24-PZ3S-R01	11/04/98	BARIUM	60.7000	J	UG/L	0.4000
OW24-PZ3S-R01	11/04/98	BENZENE	1.1000		UG/L	1.0000
OW24-PZ3S-R01	11/04/98	BERYLLIUM	0.2600	J	UG/L	0.2000
OW24-PZ3S-R01	11/04/98	CALCIUM	15800.0000		UG/L	28.0000
OW24-PZ3S-R01	11/04/98	CHROMIUM	6.2000	B	UG/L	0.7000
OW24-PZ3S-R01	11/04/98	CIS-1,2-DICHLOROETHENE	500.0000		UG/L	100.0000
OW24-PZ3S-R01	11/04/98	COBALT	2.1000	J	UG/L	0.6000
OW24-PZ3S-R01	11/04/98	COPPER	6.8000	B	UG/L	0.6000
OW24-PZ3S-R01	11/04/98	CYANIDE	7.3000	B	UG/L	5.0000
OW24-PZ3S-R01	11/04/98	FLUORENE	1.2000	K	UG/L	0.4300
OW24-PZ3S-R01	11/04/98	IRON	77700.0000		UG/L	23.5000
OW24-PZ3S-R01	11/04/98	LEAD	5.3000		UG/L	1.7000
OW24-PZ3S-R01	11/04/98	MAGNESIUM	6100.0000		UG/L	24.2000
OW24-PZ3S-R01	11/04/98	MANGANESE	80.0000		UG/L	1.1000
OW24-PZ3S-R01	11/04/98	METHYLENE CHLORIDE	0.6000	B	UG/L	2.0000
OW24-PZ3S-R01	11/04/98	NAPHTHALENE	1.4000	K	UG/L	2.2000
OW24-PZ3S-R01	11/04/98	NICKEL	5.4000	B	UG/L	1.3000
OW24-PZ3S-R01	11/04/98	POTASSIUM	1400.0000	J	UG/L	20.2000
OW24-PZ3S-R01	11/04/98	SELENIUM	5.3000	B	UG/L	1.9000
OW24-PZ3S-R01	11/04/98	SODIUM	9240.0000	B	UG/L	210.0000
OW24-PZ3S-R01	11/04/98	TRANS-1,2-DICHLOROETHENE	65.0000	J	UG/L	100.0000
OW24-PZ3S-R01	11/04/98	TRICHLOROETHENE	0.6000	J	UG/L	1.0000
OW24-PZ3S-R01	11/04/98	VANADIUM	8.2000	L	UG/L	0.8000
OW24-PZ3S-R01	11/04/98	VINYL CHLORIDE	2.5000		UG/L	1.0000
OW24-PZ3S-R01	11/04/98	ZINC	20.2000	B	UG/L	2.0000

Notes:
B = Chemical found in the sample at levels nearly equivalent to the blank
K = Biased high so actual value is possbley lower
L = Biased low and actual value possibly higher

Appendix A-3

Summary of Non-Detected Chemicals in SWMU 24 Groundwater where the Detection Limit Exceeded the Screening Level or MCL

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW01-MW02-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW01-MW02-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW01-MW02-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW01-MW02-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW01-MW02-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW01-MW02-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW01-MW02-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW01-MW02-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-MW02-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW01-MW02-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW01-MW02-R01	BENZO(A)PYRENE	0.11	U	UG/L	0.11	0.0092	RBC Tap	12.0
OW01-MW02-R01	BENZO(B)FLUORANTHENE	0.43	U	UG/L	0.43	0.092	RBC Tap	4.7
OW01-MW02-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW01-MW02-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-MW02-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW01-MW02-R01	DIBENZ(A,H)ANTHRACENE	0.22	U	UG/L	0.22	0.0092	RBC Tap	23.9
OW01-MW02-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW01-MW02-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW01-MW02-R01	INDENO(1,2,3-CD)PYRENE	0.43	U	UG/L	0.43	0.092	RBC Tap	4.7
OW01-MW02-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW01-MW03-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW01-MW03-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW01-MW03-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW01-MW03-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW01-MW03-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW01-MW03-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW01-MW03-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW01-MW03-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-MW03-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW01-MW03-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW01-MW03-R01	BENZO(A)PYRENE	0.1	U	UG/L	0.1	0.0092	RBC Tap	10.9
OW01-MW03-R01	BENZO(B)FLUORANTHENE	0.4	U	UG/L	0.4	0.092	RBC Tap	4.3
OW01-MW03-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW01-MW03-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-MW03-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW01-MW03-R01	DIBENZ(A,H)ANTHRACENE	0.2	U	UG/L	0.2	0.0092	RBC Tap	21.7
OW01-MW03-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW01-MW03-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW01-MW03-R01	INDENO(1,2,3-CD)PYRENE	0.4	U	UG/L	0.4	0.092	RBC Tap	4.3
OW01-MW03-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW01-MW04P-R01	1,1,1,2-TETRACHLOROETHANE	10	U	UG/L	10	0.41	RBC Tap	24.4
OW01-MW04P-R01	1,1,2,2-TETRACHLOROETHANE	10	U	UG/L	10	0.053	RBC Tap	188.7
OW01-MW04P-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	0.19	RBC Tap	52.6
OW01-MW04P-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	0.044	RBC Tap	227.3
OW01-MW04P-R01	1,2,3-TRICHLOROPROPANE	10	U	UG/L	10	0.0015	RBC Tap	6666.7
OW01-MW04P-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.00075	RBC Tap	13333.3
OW01-MW04P-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	0.12	RBC Tap	83.3
OW01-MW04P-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	0.16	RBC Tap	62.5
OW01-MW04P-R01	1,4-DICHLOROBENZENE	10	U	UG/L	10	0.47	RBC Tap	21.3
OW01-MW04P-R01	BENZENE	10	U	UG/L	10	0.36	RBC Tap	27.8
OW01-MW04P-R01	BENZO(A)ANTHRACENE	1.1	U	UG/L	1.1	0.092	RBC Tap	12.0
OW01-MW04P-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.0092	RBC Tap	1195.7
OW01-MW04P-R01	BENZO(B)FLUORANTHENE	43	U	UG/L	43	0.092	RBC Tap	467.4
OW01-MW04P-R01	BENZO(K)FLUORANTHENE	86	U	UG/L	86	0.92	RBC Tap	93.5
OW01-MW04P-R01	BROMODICHLOROMETHANE	10	U	UG/L	10	0.17	RBC Tap	58.8
OW01-MW04P-R01	BROMOFORM	10	U	UG/L	10	2.3	RBC Tap	4.3
OW01-MW04P-R01	BROMOMETHANE	10	U	UG/L	10	8.5	RBC Tap	1.2
OW01-MW04P-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	0.16	RBC Tap	62.5
OW01-MW04P-R01	CHLOROETHANE	10	U	UG/L	10	3.6	RBC Tap	2.8
OW01-MW04P-R01	CHLOROMETHANE	10	U	UG/L	10	1.5	RBC Tap	6.7
OW01-MW04P-R01	DIBENZ(A,H)ANTHRACENE	22	U	UG/L	22	0.0092	RBC Tap	2391.3
OW01-MW04P-R01	DIBROMOCHLOROMETHANE	10	U	UG/L	10	0.13	RBC Tap	76.9
OW01-MW04P-R01	HEXACHLORO-1,3-BUTADIENE	10	U	UG/L	10	0.14	RBC Tap	71.4
OW01-MW04P-R01	INDENO(1,2,3-CD)PYRENE	43	U	UG/L	43	0.092	RBC Tap	467.4
OW01-MW04P-R01	TETRACHLOROETHENE	10	U	UG/L	10	1.1	RBC Tap	9.1
OW01-MW04P-R01	TRICHLOROETHENE	10	U	UG/L	10	1.6	RBC Tap	6.3
OW01-MW04P-R01	VINYL CHLORIDE	10	U	UG/L	10	0.019	RBC Tap	526.3
OW01-MW04-R01	1,1,1,2-TETRACHLOROETHANE	5	UL	UG/L	5	0.41	RBC Tap	12.2
OW01-MW04-R01	1,1,2,2-TETRACHLOROETHANE	5	UL	UG/L	5	0.053	RBC Tap	94.3
OW01-MW04-R01	1,1,2-TRICHLOROETHANE	5	UL	UG/L	5	0.19	RBC Tap	26.3
OW01-MW04-R01	1,1-DICHLOROETHENE	5	UL	UG/L	5	0.044	RBC Tap	113.6
OW01-MW04-R01	1,2,3-TRICHLOROPROPANE	5	UL	UG/L	5	0.0015	RBC Tap	3333.3

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW01-MW04-R01	1,2-DIBROMOETHANE	5	UL	UG/L	5	0.00075	RBC Tap	6666.7
OW01-MW04-R01	1,2-DICHLOROETHANE	5	UL	UG/L	5	0.12	RBC Tap	41.7
OW01-MW04-R01	1,2-DICHLOROPROPANE	5	UL	UG/L	5	0.16	RBC Tap	31.3
OW01-MW04-R01	1,4-DICHLOROBENZENE	5	UL	UG/L	5	0.47	RBC Tap	10.6
OW01-MW04-R01	BENZO(A)ANTHRACENE	1.1	U	UG/L	1.1	0.092	RBC Tap	12.0
OW01-MW04-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.0092	RBC Tap	1195.7
OW01-MW04-R01	BENZO(B)FLUORANTHENE	42	U	UG/L	42	0.092	RBC Tap	456.5
OW01-MW04-R01	BENZO(K)FLUORANTHENE	84	U	UG/L	84	0.92	RBC Tap	91.3
OW01-MW04-R01	BROMODICHLOROMETHANE	5	UL	UG/L	5	0.17	RBC Tap	29.4
OW01-MW04-R01	BROMOFORM	5	UL	UG/L	5	2.3	RBC Tap	2.2
OW01-MW04-R01	CARBON TETRACHLORIDE	5	UL	UG/L	5	0.16	RBC Tap	31.3
OW01-MW04-R01	CHLOROETHANE	5	UL	UG/L	5	3.6	RBC Tap	1.4
OW01-MW04-R01	CHLOROMETHANE	5	UL	UG/L	5	1.5	RBC Tap	3.3
OW01-MW04-R01	DIBENZ(A,H)ANTHRACENE	21	U	UG/L	21	0.0092	RBC Tap	2282.6
OW01-MW04-R01	DIBROMOCHLOROMETHANE	5	UL	UG/L	5	0.13	RBC Tap	38.5
OW01-MW04-R01	HEXACHLORO-1,3-BUTADIENE	5	UL	UG/L	5	0.14	RBC Tap	35.7
OW01-MW04-R01	INDENO(1,2,3-CD)PYRENE	42	U	UG/L	42	0.092	RBC Tap	456.5
OW01-MW04-R01	TETRACHLOROETHENE	5	UL	UG/L	5	1.1	RBC Tap	4.5
OW01-MW04-R01	TRICHLOROETHENE	5	UL	UG/L	5	1.6	RBC Tap	3.1
OW01-MW04-R01	VINYL CHLORIDE	5	UL	UG/L	5	0.019	RBC Tap	263.2
OW01-MW05-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW01-MW05-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW01-MW05-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW01-MW05-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW01-MW05-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW01-MW05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW01-MW05-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW01-MW05-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-MW05-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW01-MW05-R01	BENZO(A)ANTHRACENE	0.21	U	UG/L	0.21	0.092	RBC Tap	2.3
OW01-MW05-R01	BENZO(A)PYRENE	2.1	U	UG/L	2.1	0.0092	RBC Tap	228.3
OW01-MW05-R01	BENZO(B)FLUORANTHENE	8.3	U	UG/L	8.3	0.092	RBC Tap	90.2
OW01-MW05-R01	BENZO(K)FLUORANTHENE	17	U	UG/L	17	0.92	RBC Tap	18.5
OW01-MW05-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW01-MW05-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-MW05-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW01-MW05-R01	DIBENZ(A,H)ANTHRACENE	4.2	U	UG/L	4.2	0.0092	RBC Tap	456.5
OW01-MW05-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW01-MW05-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW01-MW05-R01	INDENO(1,2,3-CD)PYRENE	8.3	U	UG/L	8.3	0.092	RBC Tap	90.2
OW01-MW05-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW01-PZ03-R01	1,1,1,2-TETRACHLOROETHANE	10	U	UG/L	10	0.41	RBC Tap	24.4
OW01-PZ03-R01	1,1,2,2-TETRACHLOROETHANE	10	U	UG/L	10	0.053	RBC Tap	188.7
OW01-PZ03-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	0.19	RBC Tap	52.6
OW01-PZ03-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	0.044	RBC Tap	227.3
OW01-PZ03-R01	1,2,3-TRICHLOROPROPANE	10	U	UG/L	10	0.0015	RBC Tap	6666.7
OW01-PZ03-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.00075	RBC Tap	13333.3
OW01-PZ03-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	0.12	RBC Tap	83.3
OW01-PZ03-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	0.16	RBC Tap	62.5
OW01-PZ03-R01	1,4-DICHLOROBENZENE	10	U	UG/L	10	0.47	RBC Tap	21.3
OW01-PZ03-R01	BENZO(A)ANTHRACENE	0.11	U	UG/L	0.11	0.092	RBC Tap	1.2
OW01-PZ03-R01	BENZO(A)PYRENE	1.1	U	UG/L	1.1	0.0092	RBC Tap	119.6
OW01-PZ03-R01	BENZO(B)FLUORANTHENE	4.2	U	UG/L	4.2	0.092	RBC Tap	45.7
OW01-PZ03-R01	BENZO(K)FLUORANTHENE	8.4	U	UG/L	8.4	0.92	RBC Tap	9.1
OW01-PZ03-R01	BROMODICHLOROMETHANE	10	U	UG/L	10	0.17	RBC Tap	58.8
OW01-PZ03-R01	BROMOFORM	10	U	UG/L	10	2.3	RBC Tap	4.3
OW01-PZ03-R01	BROMOMETHANE	10	U	UG/L	10	8.5	RBC Tap	1.2
OW01-PZ03-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	0.16	RBC Tap	62.5
OW01-PZ03-R01	CHLOROETHANE	10	U	UG/L	10	3.6	RBC Tap	2.8
OW01-PZ03-R01	CHLOROMETHANE	10	U	UG/L	10	1.5	RBC Tap	6.7
OW01-PZ03-R01	DIBENZ(A,H)ANTHRACENE	2.1	U	UG/L	2.1	0.0092	RBC Tap	228.3
OW01-PZ03-R01	DIBROMOCHLOROMETHANE	10	U	UG/L	10	0.13	RBC Tap	76.9
OW01-PZ03-R01	HEXACHLORO-1,3-BUTADIENE	10	U	UG/L	10	0.14	RBC Tap	71.4
OW01-PZ03-R01	INDENO(1,2,3-CD)PYRENE	4.2	U	UG/L	4.2	0.092	RBC Tap	45.7
OW01-PZ03-R01	TETRACHLOROETHENE	10	U	UG/L	10	1.1	RBC Tap	9.1
OW01-PZ03-R01	TRICHLOROETHENE	10	U	UG/L	10	1.6	RBC Tap	6.3
OW01-PZ03-R01	VINYL CHLORIDE	10	U	UG/L	10	0.019	RBC Tap	526.3
OW01-PZ04-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW01-PZ04-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW01-PZ04-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW01-PZ04-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW01-PZ04-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW01-PZ04-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW01-PZ04-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW01-PZ04-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-PZ04-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW01-PZ04-R01	BENZO(A)PYRENE	0.53	U	UG/L	0.53	0.0092	RBC Tap	57.6
OW01-PZ04-R01	BENZO(B)FLUORANTHENE	2.1	U	UG/L	2.1	0.092	RBC Tap	22.8
OW01-PZ04-R01	BENZO(K)FLUORANTHENE	4.3	U	UG/L	4.3	0.92	RBC Tap	4.7
OW01-PZ04-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW01-PZ04-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-PZ04-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW01-PZ04-R01	DIBENZ(A,H)ANTHRACENE	1.1	U	UG/L	1.1	0.0092	RBC Tap	119.6
OW01-PZ04-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW01-PZ04-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW01-PZ04-R01	INDENO(1,2,3-CD)PYRENE	2.1	U	UG/L	2.1	0.092	RBC Tap	22.8
OW01-PZ04-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW01-PZ05-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW01-PZ05-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW01-PZ05-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW01-PZ05-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW01-PZ05-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW01-PZ05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW01-PZ05-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW01-PZ05-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-PZ05-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW01-PZ05-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW01-PZ05-R01	BENZO(A)PYRENE	0.1	U	UG/L	0.1	0.0092	RBC Tap	10.9
OW01-PZ05-R01	BENZO(B)FLUORANTHENE	0.41	U	UG/L	0.41	0.092	RBC Tap	4.5
OW01-PZ05-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW01-PZ05-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW01-PZ05-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW01-PZ05-R01	DIBENZ(A,H)ANTHRACENE	0.2	U	UG/L	0.2	0.0092	RBC Tap	21.7
OW01-PZ05-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW01-PZ05-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW01-PZ05-R01	INDENO(1,2,3-CD)PYRENE	0.41	U	UG/L	0.41	0.092	RBC Tap	4.5
OW01-PZ05-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-MW10-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-MW10-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-MW10-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-MW10-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-MW10-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-MW10-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-MW10-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-MW10-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW10-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-MW10-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW1-MW10-R01	BENZO(A)PYRENE	0.11	U	UG/L	0.11	0.0092	RBC Tap	12.0
OW1-MW10-R01	BENZO(B)FLUORANTHENE	0.45	U	UG/L	0.45	0.092	RBC Tap	4.9
OW1-MW10-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-MW10-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW10-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-MW10-R01	DIBENZ(A,H)ANTHRACENE	0.22	U	UG/L	0.22	0.0092	RBC Tap	23.9
OW1-MW10-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-MW10-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-MW10-R01	INDENO(1,2,3-CD)PYRENE	0.45	U	UG/L	0.45	0.092	RBC Tap	4.9
OW1-MW10-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-MW6-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-MW6-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-MW6-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-MW6-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-MW6-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-MW6-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-MW6-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-MW6-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW6-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-MW6-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW1-MW6-R01	BENZO(A)PYRENE	0.1	U	UG/L	0.1	0.0092	RBC Tap	10.9
OW1-MW6-R01	BENZO(B)FLUORANTHENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-MW6-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-MW6-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW6-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-MW6-R01	DIBENZ(A,H)ANTHRACENE	0.21	U	UG/L	0.21	0.0092	RBC Tap	22.8
OW1-MW6-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW1-MW6-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-MW6-R01	INDENO(1,2,3-CD)PYRENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-MW6-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-MW7D-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-MW7D-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-MW7D-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-MW7D-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-MW7D-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-MW7D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-MW7D-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-MW7D-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW7D-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-MW7D-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW1-MW7D-R01	BENZO(A)PYRENE	0.1	U	UG/L	0.1	0.0092	RBC Tap	10.9
OW1-MW7D-R01	BENZO(B)FLUORANTHENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-MW7D-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-MW7D-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW7D-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-MW7D-R01	DIBENZ(A,H)ANTHRACENE	0.21	U	UG/L	0.21	0.0092	RBC Tap	22.8
OW1-MW7D-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-MW7D-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-MW7D-R01	INDENO(1,2,3-CD)PYRENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-MW7D-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-MW7-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-MW7-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-MW7-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-MW7-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-MW7-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-MW7-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-MW7-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-MW7-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW7-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-MW7-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW1-MW7-R01	BENZO(A)PYRENE	0.1	U	UG/L	0.1	0.0092	RBC Tap	10.9
OW1-MW7-R01	BENZO(B)FLUORANTHENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-MW7-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-MW7-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW7-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-MW7-R01	DIBENZ(A,H)ANTHRACENE	0.21	U	UG/L	0.21	0.0092	RBC Tap	22.8
OW1-MW7-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-MW7-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-MW7-R01	INDENO(1,2,3-CD)PYRENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-MW7-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-MW8D-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-MW8D-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-MW8D-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-MW8D-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-MW8D-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-MW8D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-MW8D-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-MW8D-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW8D-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-MW8D-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW1-MW8D-R01	BENZO(A)PYRENE	0.5	U	UG/L	0.5	0.0092	RBC Tap	54.3
OW1-MW8D-R01	BENZO(B)FLUORANTHENE	2	U	UG/L	2	0.092	RBC Tap	21.7
OW1-MW8D-R01	BENZO(K)FLUORANTHENE	4	U	UG/L	4	0.92	RBC Tap	4.3
OW1-MW8D-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-MW8D-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW8D-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-MW8D-R01	DIBENZ(A,H)ANTHRACENE	1	U	UG/L	1	0.0092	RBC Tap	108.7
OW1-MW8D-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-MW8D-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-MW8D-R01	INDENO(1,2,3-CD)PYRENE	2	U	UG/L	2	0.092	RBC Tap	21.7
OW1-MW8D-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-MW8-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-MW8-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-MW8-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-MW8-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-MW8-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-MW8-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-MW8-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-MW8-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW1-MW8-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-MW8-R01	BENZO(A)PYRENE	0.1	U	UG/L	0.1	0.0092	RBC Tap	10.9
OW1-MW8-R01	BENZO(B)FLUORANTHENE	0.41	U	UG/L	0.41	0.092	RBC Tap	4.5
OW1-MW8-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-MW8-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-MW8-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-MW8-R01	DIBENZ(A,H)ANTHRACENE	0.2	U	UG/L	0.2	0.0092	RBC Tap	21.7
OW1-MW8-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-MW8-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-MW8-R01	INDENO(1,2,3-CD)PYRENE	0.41	U	UG/L	0.41	0.092	RBC Tap	4.5
OW1-MW8-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-PZ1-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-PZ1-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-PZ1-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-PZ1-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-PZ1-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-PZ1-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-PZ1-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-PZ1-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-PZ1-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-PZ1-R01	BENZENE	1	U	UG/L	1	0.36	RBC Tap	2.8
OW1-PZ1-R01	BENZO(B)FLUORANTHENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-PZ1-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-PZ1-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-PZ1-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-PZ1-R01	DIBENZ(A,H)ANTHRACENE	0.21	U	UG/L	0.21	0.0092	RBC Tap	22.8
OW1-PZ1-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-PZ1-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-PZ1-R01	INDENO(1,2,3-CD)PYRENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-PZ1-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-PZ2P-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-PZ2P-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-PZ2P-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-PZ2P-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-PZ2P-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-PZ2P-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-PZ2P-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-PZ2P-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-PZ2P-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-PZ2P-R01	BENZO(A)PYRENE	0.1	U	UG/L	0.1	0.0092	RBC Tap	10.9
OW1-PZ2P-R01	BENZO(B)FLUORANTHENE	0.41	U	UG/L	0.41	0.092	RBC Tap	4.5
OW1-PZ2P-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-PZ2P-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-PZ2P-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-PZ2P-R01	DIBENZ(A,H)ANTHRACENE	0.2	U	UG/L	0.2	0.0092	RBC Tap	21.7
OW1-PZ2P-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-PZ2P-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-PZ2P-R01	INDENO(1,2,3-CD)PYRENE	0.41	U	UG/L	0.41	0.092	RBC Tap	4.5
OW1-PZ2P-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW1-PZ2-R01	1,1,1,2-TETRACHLOROETHANE	1	U	UG/L	1	0.41	RBC Tap	2.4
OW1-PZ2-R01	1,1,2,2-TETRACHLOROETHANE	1	U	UG/L	1	0.053	RBC Tap	18.9
OW1-PZ2-R01	1,1,2-TRICHLOROETHANE	1	U	UG/L	1	0.19	RBC Tap	5.3
OW1-PZ2-R01	1,1-DICHLOROETHENE	1	U	UG/L	1	0.044	RBC Tap	22.7
OW1-PZ2-R01	1,2,3-TRICHLOROPROPANE	1	U	UG/L	1	0.0015	RBC Tap	666.7
OW1-PZ2-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.00075	RBC Tap	1333.3
OW1-PZ2-R01	1,2-DICHLOROETHANE	1	U	UG/L	1	0.12	RBC Tap	8.3
OW1-PZ2-R01	1,2-DICHLOROPROPANE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-PZ2-R01	1,4-DICHLOROBENZENE	1	U	UG/L	1	0.47	RBC Tap	2.1
OW1-PZ2-R01	BENZO(A)PYRENE	0.11	U	UG/L	0.11	0.0092	RBC Tap	12.0
OW1-PZ2-R01	BENZO(B)FLUORANTHENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-PZ2-R01	BROMODICHLOROMETHANE	1	U	UG/L	1	0.17	RBC Tap	5.9
OW1-PZ2-R01	CARBON TETRACHLORIDE	1	U	UG/L	1	0.16	RBC Tap	6.3
OW1-PZ2-R01	CHLOROFORM	1	U	UG/L	1	0.15	RBC Tap	6.7
OW1-PZ2-R01	DIBENZ(A,H)ANTHRACENE	0.21	U	UG/L	0.21	0.0092	RBC Tap	22.8
OW1-PZ2-R01	DIBROMOCHLOROMETHANE	1	U	UG/L	1	0.13	RBC Tap	7.7
OW1-PZ2-R01	HEXACHLORO-1,3-BUTADIENE	1	U	UG/L	1	0.14	RBC Tap	7.1
OW1-PZ2-R01	INDENO(1,2,3-CD)PYRENE	0.42	U	UG/L	0.42	0.092	RBC Tap	4.6
OW1-PZ2-R01	VINYL CHLORIDE	1	U	UG/L	1	0.019	RBC Tap	52.6
OW01-MW02-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-MW03-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-MW04P-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	7	MCL	1.4

SAMPLE_ID	CHEM_NAME	ANA_VALUE	DV_QUAL	UNITS	DETECT_LIM	RegCritValue	Criteria	Exceedance Quotient
OW01-MW04P-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.05	MCL	200.0
OW01-MW04P-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	BENZENE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.2	MCL	55.0
OW01-MW04P-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	TETRACHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	TRICHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-MW04P-R01	VINYL CHLORIDE	10	U	UG/L	10	2	MCL	5.0
OW01-MW04-R01	1,1,2-TRICHLOROETHANE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	1,2-DIBROMOETHANE	5	UL	UG/L	5	0.05	MCL	100.0
OW01-MW04-R01	1,2-DICHLOROETHANE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	1,2-DICHLOROPROPANE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	BENZO(A)PYRENE	11	U	UG/L	11	0.2	MCL	55.0
OW01-MW04-R01	CARBON TETRACHLORIDE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	TETRACHLOROETHENE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	TRICHLOROETHENE	5	UL	UG/L	5	5	MCL	1.0
OW01-MW04-R01	VINYL CHLORIDE	5	UL	UG/L	5	2	MCL	2.5
OW01-MW05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-MW05-R01	BENZO(A)PYRENE	2.1	U	UG/L	2.1	0.2	MCL	10.5
OW01-PZ03-R01	1,1,2-TRICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	1,1-DICHLOROETHENE	10	U	UG/L	10	7	MCL	1.4
OW01-PZ03-R01	1,2-DIBROMOETHANE	10	U	UG/L	10	0.05	MCL	200.0
OW01-PZ03-R01	1,2-DICHLOROETHANE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	1,2-DICHLOROPROPANE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	BENZO(A)PYRENE	1.1	U	UG/L	1.1	0.2	MCL	5.5
OW01-PZ03-R01	CARBON TETRACHLORIDE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	TETRACHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	TRICHLOROETHENE	10	U	UG/L	10	5	MCL	2.0
OW01-PZ03-R01	VINYL CHLORIDE	10	U	UG/L	10	2	MCL	5.0
OW01-PZ04-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW01-PZ04-R01	BENZO(A)PYRENE	0.53	U	UG/L	0.53	0.2	MCL	2.7
OW01-PZ05-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW10-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW6-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW7D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW7-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW8D-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-MW8D-R01	BENZO(A)PYRENE	0.5	U	UG/L	0.5	0.2	MCL	2.5
OW1-MW8-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-PZ1-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-PZ2P-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0
OW1-PZ2-R01	1,2-DIBROMOETHANE	1	U	UG/L	1	0.05	MCL	20.0

Notes:

U = Non-detects at the detection limit

UL = Non-detected but biased low, the actual concentration is possibly higher

Appendix E
ARARs

Table E-1
Federal Location-Specific ARARs
SWMUs 1, 15, and 24, NAS Oceana, Virginia Beach, Virginia

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Executive Order 11988, Protection of Floodplain*					
Within floodplain	Actions taken should avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values.	Action that will occur in a floodplain, i.e., lowlands, and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	40 CFR Part 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Not applicable	No remedial activities are to be conducted in a floodplain.
Executive Order 11990, Protection of Wetlands*					
Wetland	Action to minimize the destruction, loss, or degradation of wetlands.	Wetland as defined by Executive Order 11990 Section 7.	40 CFR 6, Appendix A; excluding Sections 6(a)(2), 6(a)(4), 6(a)(6); 40 CFR 6.302	Relevant and appropriate	Federal or state regulated wetlands are present at the base in areas surrounding SWMUs 1 and 15, although not located within the SWMU boundaries.
Clean Water Act, Section 404*					
Wetland	Action to prohibit discharge of dredged or fill material into wetland without permit.	Wetland as defined by Executive Order 11990 Section 7.	40 CFR 230.10; 40 CFR 231 (231.1, 231.2, 231.7, 231.8)	Not applicable	No discharge of dredged or fill material to a wetland is planned as part of the response action.
Endangered Species Act of 1978*					
Endangered species	Action to ensure that any action is not likely to jeopardize the continued existence of endangered or threatened species or adversely affect its critical habitat.	Applies to actions that affect endangered or threatened species or their habitat.	16 USC 1531 50 CFR Part 402	Relevant and appropriate	No state or federally listed threatened or endangered species were found to exist at NASO except for transient individuals. Two rare/extremely rare plant species were found at the base, however. Therefore, the requirements of the Endangered Species Act of 1973 (16 USC 1536(a)) are relevant and appropriate to remediation activities occurring at SWMUs 1, 15, and 24.
Migratory bird area	Protects almost all species of native birds in the U.S. from unregulated taking which can include poisoning at hazardous waste sites	Presence of migratory birds	16 USC Section 703	Relevant and appropriate	Migratory birds are encountered at the base. These requirements are relevant and appropriate to any response actions that could result in unregulated "taking" of native birds.

Table E-1
Federal Location-Specific ARARs
SWMUs 1, 15, and 24, NAS Oceana, Virginia Beach, Virginia

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comment
* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that DON accepts the entire statues or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.					
ARARs - Applicable or relevant and appropriate requirements. CFR - Code of Federal Regulations. USC - United States Code. FR – Federal Regulation					

Table E-2
Virginia Location-Specific ARARs
SWMUs 1, 15, and 24, NAS Oceana, Virginia Beach, Virginia

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Virginia State Water Control Laws and Virginia Wetlands Regulations*					
Wetland	Action to minimize the destruction, loss, or degradation of wetlands.	Wetland as defined by Virginia statutory provision.	Virginia Code Sections 62.1-44.15:5	Relevant and appropriate	Federal and/or state regulated wetlands are present at the base in areas surrounding SWMUs 1 and 15, although not located within the SWMU boundaries.
Surface waters and adjacent land	No person shall dredge, fill, or discharge any pollutant into, or adjacent to surface waters, or otherwise alter the physical, chemical, or biological properties of surface waters, except as authorized pursuant to a Virginia Water Protection Permit, a Virginia Pollution Discharge Elimination System Permit, or a Virginia Pollution Abatement Permit	Dredging, filling, or discharging of pollutants	Virginia Code Ann 62.1-44.2 to 44.4; 9 VAC 25-210-10; 9 VAC 25-31-10 to 940; 9 VAC 25-32-10 to 300	Not applicable	No dredging or filling activities are expected to occur at SWMUs 1, 15, and 24.
Chesapeake Bay Preservation Act and Chesapeake Bay Preservation Area Designation and Management Regulations*					
Chesapeake Bay areas	Under these requirements, certain locally designated tidal and nontidal wetlands, as well as other sensitive land areas, may be subject to limitations regarding land-disturbing activities, removal of vegetation, use of impervious cover, erosion and sediment control, stormwater management, and other aspects of land use that may have effects on water quality.	Local jurisdiction and designation as a Chesapeake Bay Preservation area.	Code of Virginia Section 10.1-2100 et seq. and 9 VAC 10-20-10	TBC	This requirement is not an ARAR since the area affected by the response action is federally owned and the City of Virginia Beach does not have jurisdiction over the Naval Base. Compliance is voluntary based on a memorandum of agreement.
Coastal Zone Management Act*; State Coastal Zone Management Programs and Consistency Determinations					
Within coastal zone	Conduct activities within a coastal Management Zone in a manner consistent with state requirements.	Activities affecting the coastal zone including lands thereunder and adjacent shore land.	Section 307(c) of 16 USC 1456(c); also see 15 CFR 930 and 923.45	TBC	This requirement is not an ARAR since the Commonwealth of Virginia does not have jurisdiction over the federally owned Naval Base. Compliance is on a voluntary basis.

Table E-2
Virginia Location-Specific ARARs
SWMUs 1, 15, and 24, NAS Oceana, Virginia Beach, Virginia

Location	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Virginia Endangered Species Act*					
Critical habitat upon which endangered species or threatened species depend.	Action to conserve endangered species or threatened species, including consultation with the Virginia Board of Game and Inland Fisheries.	Determination of effect upon endangered or threatened species or its habitat.	Code of Virginia Sections 29.1-563 through 568 4 VAC 15-20-130	Relevant and appropriate	No state or federally listed threatened or endangered species were found to exist at NASO except for transient individuals. Two rare/extremely rare plant species were identified at the base and are protected by the Virginia endangered plant and insect species act. Therefore, the requirements of the Virginia Endangered Species Act are relevant and appropriate to remediation activities occurring at SWMUs 1, 15, and 24.
Virginia Natural Areas Preserves Act*					
Natural preserves area	Action to conserve natural preserves areas and restrict certain activities in these areas	Applicable to sites that meet natural preserve area criteria as determined by the Virginia Department of Conservation and Recreation	Code of Virginia Sections 10.1-209 through 217	Not Applicable	SWMUs 1, 15, and 24 are not natural preserves areas.
Virginia Endangered Plant and Insect Species Act; Virginia Board of Game and Inland Fisheries*					
Endangered plant and insect species	Action to conserve endangered or protected plant and insect species	Applies to actions that affect endangered or protected plant and insect species.	Code of Virginia Sections 29.1-100 and 29.1-565 2 VAC 5-320-10	Relevant and Appropriate	Two rare plant species were identified on base. Therefore, the requirements of the Virginia Endangered Plant and Insect Species Act are relevant and appropriate to remediation activities occurring at SWMUs 1, 15, and 24.

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that Navy accepts the entire statutes or policies as potential ARARs. Specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.

ARARs- Applicable or relevant and appropriate requirements
VAC – Virginia Administrative Code
USC – United States Code
CFR – Code of Federal Regulations

Table E-3
Federal Action-Specific ARARs
SWMUs 1, 15, and 24, NAS Oceana, Virginia Beach, Virginia

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Clean Air Act (CAA) 40 USC 7401 et seq.*					
Discharge to air	National Primary and Secondary Ambient Air Quality Standards (NAAQS) - standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare	40 CFR Sections 50.4 - 50.12	TBC	Not an ARAR; Federal NAAQS are nonenforceable standards. May be a TBC for site remediation activities (i.e. earthwork activities such as tilling and drilling for well installation).

* Statutes and policies, and their citations, are provided as headings to identify general categories of ARARs. Specific potential ARARs are addressed in the table below each general heading.

TBC- To Be Considered

CAA – Clean Air Act

RCRA – Resource Conservation and Recovery Act

ARAR – Applicable Relevant and Appropriate Requirements

CFR- Code of Federal Regulations

USC- United States Code

NAAQS- National Ambient Air Quality Standards (Primary and Secondary)

Table E-4
Virginia Action-Specific ARARs
SWMUs 1, 15, and 24, NAS Oceana, Virginia Beach, Virginia

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Virginia Air Pollution Control Regulations*					
Discharge to air	Virginia Ambient Air Quality Standards - standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare.	VR 120-03-02, VR-120-030-06 & 9 VAC 5-30-10	Applicable.	Applicable for all site remediation activities that may generate air discharges.
Discharge of visible emissions and fugitive dust	Fugitive dust/emissions may not be discharged to the atmosphere at amounts in excess of standards.	Any source of fugitive dust/ emissions.	VR 120-05-01 & VAC 5-50-60 to 120	Applicable.	Applicable for any site remediation activities that generate fugitive dust.
Discharge of toxic pollutants	Toxic pollutants may not be discharged to the atmosphere at amounts in excess of standards.	Any emission from the disturbance of soil, or treatment of soil or water, that do not qualify for the exemptions under Rule 4-3.	VR 120-05-01& VAC 5-50-160 to 230	Applicable.	Applicable for any site remediation activities that generate toxic air pollutants.
Virginia Stormwater Management Regulations and Virginia Erosion and Sediment Control Regulations					
Stormwater Management	Regulates stormwater management and erosion/ sedimentation control practice.	Land disturbing activities.	VR 215-02-00 & VR 625-02-00 & 4 VAC 50–30-10	Applicable.	Applicable for any site remediation activities involving surface water runoff and erosion.
Virginia Pollutant Discharge Elimination System (VPDES) Permit Regulations*					
Discharge of Treated Water to Surface Waters, and certain storm water discharges	Regulated point-source discharges through VPDES permitting program. Permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	Applicable to discharge of treated water to surface water, and to storm water dis-charges from certain facilities, including landfills.	VR 680-14-01, VR 680-15-01; 9 VAC 25-31-10 to 940	Applicable.	The base has a VPDES permit including runoff from SWMU 1.

Table E-4
Virginia Action-Specific ARARs
SWMUs 1, 15, and 24, NAS Oceana, Virginia Beach, Virginia

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comment
Hazardous Waste Management Regulations, Solid Waste Disposal Facility Standards (9 VAC 20-80); Virginia Waste Management Act*					
Hazardous Waste Staging Transport, and Disposal	These regulations and laws define the requirements for the management of hazardous wastes. Any disposal facility must be properly permitted and in compliance with all operational and monitoring requirements of the permit and regulations.	Wastes must meet definition of hazardous waste.	VR 672-10-01, 9 VAC 20-60-580	Applicable	Free-product recovered from the skimmers at SWMU 1 will be managed according to Virginia Hazardous Waste Regulations.

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs. Specific ARARs are addressed in the table below each general heading.

**Applicable, RA- Relevant and appropriate, TBC- To Be Considered

ARAR- Applicable or relevant and appropriate requirement

CFR- Code of Federal Regulations USC- United States Code

Appendix F
PRG Calculations

Table F-1
Preliminary Remediation Goals
Groundwater
Adult Residential Scenario
SWMU 1, NAS Oceana

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDi) (mg/kg-day)	Target Organ	DAevent (L/cm^2-day)	Shower Exposure (L/day)	Noncarcinogen Groundwater PRG HQ = 0.1 (mg/L)	Noncarcinogen Groundwater PRG HQ = 0.5 (mg/L)	Noncarcinogen Groundwater PRG HQ = 1 (mg/L)	Noncarcinogen PRG PRG (mg/kg)	Noncarcinogen PRG Target HQ[1] (mg/kg)
SVOCs											
Naphthalene	2.00E-02	1.60E-02	9.00E-04	body weight	6.2E-05		4.1E-02	2.1E-01	4.1E-01	4.1E-01	1.00

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn + Cn)}$$

An = 1/RfDo x IR

Bn = 1/RfDd x SA x DAevent

Cn = 1/RfDi x Shower Exposure

EXPOSURE ASSUMPTIONS	
BW - Body weight (kilograms)	70
ATnc - Averaging time for noncarcinogens (days)	8,760
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	24
IR - Ingestion rate (L/day)	2
SA - Skin surface area (cm^2)	20,000

NA - No reference dose or slope factor available.

1 Applicable HQ calculated so that total HQ for a target organ does not exceed 1.

Table F-1a
Calculation of DAevent
Groundwater, Adult
SWMU 1, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) *(cm/hr)*	Lag Time (t) *(hr)*	Duration of Event (ET) *(hr)*	t* *(hr)*	B *(dimensionless)*	DAevent (L/cm^2-day)	Eq
Naphthalene	6.9E-02	5.3E-01	2.0E-01	2.2E+00	2.0E-01	6.2E-05	2

Inorganics: DAevent (mg/cm2-event) =

PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: *DAevent (mg/cm2-event) =*

2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.

Table F-2
Preliminary Remediation Goals
Groundwater
Child Residential Scenario
SWMU 1, NAS Oceana

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDI) (mg/kg-day)	Target Organ	DAevent (L/cm^2-day)	Noncarcinogen Groundwater PRG HQ = 0.1 (mg/L)	Noncarcinogen Groundwater PRG HQ = 0.5 (mg/L)	Noncarcinogen Groundwater PRG HQ = 1 (mg/L)	Noncarcinogen PRG PRG (mg/L)	Noncarcinogen PRG Target HQ[1]
SVOCs										
Naphthalene	2.00E-02	1.60E-02	9.00E-04	body weight	8.0E-05	1.7E-02	8.7E-02	1.7E-01	1.7E-01	1.00

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn)}$$

An = 1/RfDo x IR

Bn = 1/RfDd x SA x DAevent

EXPOSURE ASSUMPTIONS	
BW - Body weight (kilograms)	15
ATnc - Averaging time for noncarcinogens (days)	2,190
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	6
IR - Ingestion rate (L/day)	1
SA - Skin surface area (cm^2)	7,930

NA - No reference dose or slope factor available.

1 Applicable HQ calculated so that total HQ for a target organ does not exceed 1.

Table F-2a
Calculation of DAevent
Groundwater, Child
SWMU 1, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t* (hr)	B (dimensionless)	DAevent (L/cm^2-day)	Eq
Naphthalene	6.9E-02	5.3E-01	3.3E-01	2.2E+00	2.0E-01	8.0E-05	2

Inorganics: DAevent (mg/cm2-event) =

PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.

Table F-3
Preliminary Remediation Goals
Groundwater
Lifetime Residential Scenario
SWMU 1, NAS Oceana

Chemical	Oral Slope Factor (CSFo) (kg-day/mg)	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFI) (kg-day/mg)	DAevent-a (L/cm^2-day)	DAevent-c (L/cm^2-day)	Shower Exposure (L/day)	Carcinogen PRG Risk = 1E-06 (mg/L)	Carcinogen PRG Risk = 1E-05 (mg/L)	Carcinogen PRG Risk = 1E-04 (mg/L)
SVOCs									
Naphthalene	NA	NA	NA	6.2E-05	8.0E-05				

Carcinogen calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{TR \times AT_c}{EF \times (Ac + Bc + Cc)}$$

Ac = CSFo x IRadj

Bc = CSFd x [(SAa x DAevent-a x EDa)/BWa + (SAc x DAevent-c X EDc)/BWc]

Cc = CSFi x Shower Exposure x EDa x 1/BWa

EXPOSURE ASSUMPTIONS	Lifetime	Adult (a)	Child (c)
BW - Body weight (kilograms)		70	15
ATnc - Averaging time for noncarcinogens (days)		8,760	2,190
ATc - Averaging time for carcinogens (days)		25,550	25,550
EF - Exposure frequency (days/year)		350	350
ED - Exposure duration (year)		24	6
IR - Ingestion rate (L/day)		2	1
IRdj - Ingestion rate (L-year/kg-day)	1.09		
SA - Skin surface area (cm^2)		20,000	7,930
ET - Exposure Time (hours/day)		0.20	0.33

NA - No reference dose or slope factor available.

Table F-3a
Calculation of DAevent
Groundwater, Child/Adult
SWMU 1, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ETa) (hr)	Duration of Event (ETc) (hr)	t* (hr)	B (dimensionless)	Daevent Adult (L/cm^2-day)	Daevent Child (L/cm^2-day)	Eq
Naphthalene	6.9E-02	5.3E-01	2.0E-01	3.3E-01	2.2E+00	2.0E-01	6.2E-05	8.0E-05	2

Inorganics: DAevent (mg/cm2-event) =
PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.

Table F-4
Preliminary Remediation Goals
Groundwater
Adult Residential Scenario
SWMU 15, NAS Oceana

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDi) (mg/kg-day)	Target Organ	DAevent (L/cm^2-day)	Shower Exposure (L/day)	Noncarcinogen Groundwater PRG HQ = 0.1 (mg/L)	Noncarcinogen Groundwater PRG HQ = 0.5 (mg/L)	Noncarcinogen Groundwater PRG HQ = 1 (mg/L)	Noncarcinogen PRG PRG (mg/kg)	Noncarcinogen PRG Target HQ[1] (mg/kg)
VOCs											
Benzene	3.00E-03	3.00E-03	1.70E-03	blood, immune system	6.9E-05	6.5E-03	6.4E-03	3.2E-02	6.4E-02	3.2E-02	0.50
Chloroform	1.00E-02	1.00E-02	8.60E-05	liver	2.2E-04	5.5E-03	1.0E-02	5.2E-02	1.0E-01	3.4E-02	0.33
Methylene Chloride	6.00E-02	4.80E-02	8.60E-01	liver	3.0E-06	6.1E-03	2.1E-01	1.1E+00	2.1E+00	7.0E-01	0.33
SVOCs											
Naphthalene	2.00E-02	1.60E-02	9.00E-04	body weight	6.2E-05		4.1E-02	2.1E-01		4.1E-01	1.00
Inorganics											
Arsenic	3.00E-04	2.85E-04	NA	skin, vascular	2.0E-07		1.1E-03	5.5E-03	1.1E-02	1.1E-02	1.00
Iron	3.00E-01	6.00E-02	NA	GI, blood, liver	2.0E-07		1.1E+00	5.4E+00	1.1E+01	3.6E+00	0.33
Manganese	2.00E-02	7.00E-03	1.43E-05	CNS	2.0E-07		7.3E-02	3.6E-01	7.3E-01	7.3E-01	1.00

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn + Cn)}$$

An = 1/RfDo x IR

Bn = 1/RfDd x SA x DAevent

Cn = 1/RfDi x Shower Exposure

EXPOSURE ASSUMPTIONS	
BW - Body weight (kilograms)	70
ATnc - Averaging time for noncarcinogens (days)	8,760
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	24
IR - Ingestion rate (L/day)	2
SA - Skin surface area (cm^2)	20,000

NA - No reference dose or slope factor available.

1 Applicable HQ calculated so that total HQ for a target organ does not exceed 1.

Table F-4a
Calculation of DAevent
Groundwater, Adult
SWMU 15, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t* (hr)	B (dimensionless)	DAevent (L/cm^2-day)	Eq
Benzene	1.1E-01	2.6E-01	2.0E-01	6.3E-01	1.3E-02	6.9E-05	2
Chloroform	2.6E-01	4.7E-01	2.0E-01	1.1E+00	9.3E-03	2.2E-04	2
Methylene Chloride	4.5E-03	2.9E-01	2.0E-01	6.9E-01	1.8E-03	3.0E-06	2
Naphthalene	6.9E-02	5.3E-01	2.0E-01	2.2E+00	2.0E-01	6.2E-05	2
Arsenic	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1
Iron	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1
Manganese	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1

Inorganics: DAevent (mg/cm2-event) =

PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.

Table F-4b
Inhalation Exposure Concentrations from Foster and Chrostowski Shower Model
SWMU 15, NAS Oceana

Chemical	Molecular weight (MW) (g/mole)	Henry's Law Constant (H) (atm-m^3/mole)	Kg (VOC) (cm/hr)	Kl(VOC) (cm/hr)	KL (cm/hr)	Kal (cm/hr)	Cwd	S (L/m^3-min)	Inhalation Exposure (lnExp) (L/kg-shower)	Shower Exposure (lnExp X BW) (L/day)
Benzene	78	5.4E-03	1.4E+03	1.5E+01	1.4E+01	1.9E+01	4.8E-01	3.2E+00	9.3E-05	6.5E-03
Chloroform	119	4.4E-03	1.2E+03	1.2E+01	1.2E+01	1.6E+01	4.0E-01	2.7E+00	7.9E-05	5.5E-03
Methylene Chloride	85	2.7E-03	1.4E+03	1.4E+01	1.3E+01	1.8E+01	4.5E-01	3.0E+00	8.7E-05	6.1E-03

Variables	Units	Exposure Assumptions
Kg(VOC) = gas-film mass transfer coefficient	cm/hr	Solved by Eq 1
Kl(VOC) = liquid-film mass transfer coefficient	cm/hr	Solved by Eq 2
KL = overall mass transfer coefficient	cm/hr	Solved by Eq 3
Kal = adjusted overall mass transfer coeff.	cm/hr	Solved by Eq 4
Tl = Calibration temp. of water	K (20C +273)	293
Ts = Shower water temperature	k (45C)	318
Us = water viscosity at Ts	centipoise	0.596
Ul = water viscosity at Tl	cp	1.002
Cwd = conc. leaving droplets after time sdt		Solved by Eq 5
sdt = shower droplet drop time	sec	2
d = shower droplet diameter	mm	1
FR = shower water flow rate	l/min	20
SV = shower room air volume	m^3	3
S = indoor VOC generation rate	L/m^3-min	Solved by Eq 6
VR = ventilation rate	l/min	13.8
BW = body weight	kg	70
Ds = duration of shower	min	12
Dt = total duration in shower room	min	20
R = air exchange rate	min^{-1}	0.0167
Ca = indoor air concentration of VOCs	L-ug/mg-m^3	Solved by Eq 7
Einh = inhalation exposure per shower	L/kg-shower	Solved by Eq 8

Equation 1:	Kg(VOC) =	$3000 * (18 / MW)^{0.5}$	
Equation 2:	Kl(VOC) =	$20 * (44 / MW)^{0.5}$	
Equation 3:	KL =	$((1 / Kl(VOC)) + (0.024 / (Kg (VOC) * H)))^{-1}$	
Equation 4:	Kal =	$(KL * (((Tl * Us) / (Ts * Ul))^{-0.5}))$	
Equation 5:	Cwd =	((1-EXP((-1 * Kal * sdt)/(60 * d))))	
Equation 6:	S =	(Cwd * FR / SV)	
Equation 7:	see time series example on Table I-GW-6		
Equation 8:	Einh =	If t>Ds	(((VR * S) / (BW * R * 1000000)) * ((Ds + (EXP(-R * Dt) / R)-(EXP(R * (Ds - Dt))) / R)))

Table F-5
Preliminary Remediation Goals
Groundwater
Child Residential Scenario
SWMU 15, NAS Oceana

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDi) (mg/kg-day)	Target Organ	DAevent (L/cm^2-day)	Noncarcinogen Groundwater PRG HQ = 0.1 (mg/L)	Noncarcinogen Groundwater PRG HQ = 0.5 (mg/L)	Noncarcinogen Groundwater PRG HQ = 1 (mg/L)	Noncarcinogen PRG PRG (mg/L)	Noncarcinogen PRG Target HQ[1]
VOCs										
Benzene	3.00E-03	3.00E-03	1.70E-03	blood, immune system	8.9E-05	2.8E-03	1.4E-02	2.8E-02	1.4E-02	0.50
Chloroform	1.00E-02	1.00E-02	8.60E-05	liver	2.8E-04	4.8E-03	2.4E-02	4.8E-02	1.6E-02	0.33
Methylene Chloride	6.00E-02	4.80E-02	8.60E-01	liver	3.8E-06	9.0E-02	4.5E-01	9.0E-01	3.0E-01	0.33
SVOCs										
Naphthalene	2.00E-02	1.60E-02	9.00E-04	body weight	8.0E-05	1.7E-02	8.7E-02	1.7E-01	1.7E-01	1.00
Inorganics										
Arsenic	3.00E-04	2.85E-04	NA	skin, vascular	3.3E-07	4.7E-04	2.3E-03	4.7E-03	4.7E-03	1.00
Iron	3.00E-01	6.00E-02	NA	GI, blood, liver	3.3E-07	4.6E-01	2.3E+00	4.6E+00	1.5E+00	0.33
Manganese	2.00E-02	7.00E-03	1.43E-05	CNS	3.3E-07	3.1E-02	1.6E-01	3.1E-01	3.1E-01	1.00

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn)}$$

An = 1/RfDo x IR

Bn = 1/RfDd x SA x DAevent

EXPOSURE ASSUMPTIONS	
BW - Body weight (kilograms)	15
ATnc - Averaging time for noncarcinogens (days)	2,190
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	6
IR - Ingestion rate (L/day)	1
SA - Skin surface area (cm^2)	7,930

NA - No reference dose or slope factor available.

1 Applicable HQ calculated so that total HQ for a target organ does not exceed 1.

Table F-5a
Calculation of DAevent
Groundwater, Child
SWMU 15, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t* (hr)	B (dimensionless)	DAevent (L/cm^2-day)	Eq
Benzene	1.1E-01	2.6E-01	3.3E-01	6.3E-01	1.3E-02	8.9E-05	2
Chloroform	2.6E-01	4.7E-01	3.3E-01	1.1E+00	9.3E-03	2.8E-04	2
Methylene Chloride	4.5E-03	2.9E-01	3.3E-01	6.9E-01	1.8E-03	3.8E-06	2
Naphthalene	6.9E-02	5.3E-01	3.3E-01	2.2E+00	2.0E-01	8.0E-05	2
Arsenic	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Iron	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Manganese	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1

Inorganics: DAevent (mg/cm2-event) =

PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.

Table F-6
Preliminary Remediation Goals
Groundwater
Lifetime Residential Scenario
SWMU 15, NAS Oceana

Chemical	Oral Slope Factor (CSFo) (kg-day/mg)	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFi) (kg-day/mg)	DAevent-a (L/cm^2-day)	DAevent-c (L/cm^2-day)	Shower Exposure (L/day)	Carcinogen PRG Risk = 1E-06 (mg/L)	Risk = 1E-05 (mg/L)	Risk = 1E-04 (mg/L)
VOCs									
Benzene	5.50E-02	5.5E-02	2.90E-02	6.9E-05	8.9E-05	6.5E-03	7.2E-04	7.2E-03	7.2E-02
Chloroform	6.10E-03	6.1E-03	8.10E-02	2.2E-04	2.8E-04	5.5E-03	3.4E-03	3.4E-02	3.4E-01
Methylene Chloride	7.50E-03	9.4E-03	1.65E-03	3.0E-06	3.8E-06	6.1E-03	8.6E-03	8.6E-02	8.6E-01
SVOCs									
Naphthalene	NA	NA	NA	6.2E-05	8.0E-05				
Inorganics									
Arsenic	1.50E+00	1.6E+00	1.51E+01	2.0E-07	3.3E-07		4.5E-05	4.5E-04	4.5E-03
Iron	NA	NA	NA	2.0E-07	3.3E-07				
Manganese	NA	NA	NA	2.0E-07	3.3E-07				

Carcinogen calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{TR \times AT_c}{EF \times (Ac + Bc + Cc)}$$

Ac = CSFo x IRadj

Bc = CSFd x [(SAa x DAevent-a x EDa)/BWa + (SAc x DAevent-c X EDc)/BWc]

Cc = CSFi x Shower Exposure x EDa x 1/BWa

EXPOSURE ASSUMPTIONS	Lifetime	Adult (a)	Child (c)
BW - Body weight (kilograms)		70	15
ATnc - Averaging time for noncarcinogens (days)		8,760	2,190
ATc - Averaging time for carcinogens (days)		25,550	25,550
EF - Exposure frequency (days/year)		350	350
ED - Exposure duration (year)		24	6
IR - Ingestion rate (L/day)		2	1
IRdj - Ingestion rate (L-year/kg-day)	1.09		
SA - Skin surface area (cm^2)		20,000	7,930
ET - Exposure Time (hours/day)		0.20	0.33

NA - No reference dose or slope factor available.

Table F-6a
Calculation of DAevent
Groundwater, Child/Adult
SWMU 15, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ETa) (hr)	Duration of Event (ETc) (hr)	t* (hr)	B (dimensionless)	Daevent Adult (L/cm^2-day)	Daevent Child (L/cm^2-day)	Eq
Benzene	1.1E-01	2.6E-01	2.0E-01	3.3E-01	6.3E-01	1.3E-02	6.9E-05	8.9E-05	2
Chloroform	2.6E-01	4.7E-01	2.0E-01	3.3E-01	1.1E+00	9.3E-03	2.2E-04	2.8E-04	2
Methylene Chloride	4.5E-03	2.9E-01	2.0E-01	3.3E-01	6.9E-01	1.8E-03	3.0E-06	3.8E-06	2
Naphthalene	6.9E-02	5.3E-01	2.0E-01	3.3E-01	2.2E+00	2.0E-01	6.2E-05	8.0E-05	2
Arsenic	1.0E-03	N/A	2.0E-01	3.3E-01	N/A	N/A	2.0E-07	3.3E-07	1
Iron	1.0E-03	N/A	2.0E-01	3.3E-01	N/A	N/A	2.0E-07	3.3E-07	1
Manganese	1.0E-03	N/A	2.0E-01	3.3E-01	N/A	N/A	2.0E-07	3.3E-07	1

Inorganics: DAevent (mg/cm2-event) =
PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.

Table F-7
Preliminary Remediation Goals for Soil
Residential Adult Scenario
NAS Oceana, SWMU 15

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDI) (mg/kg-day)	Oral Slope Factor (CSFo) (kg-day/mg)	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFi) (kg-day/mg)	Absorption Factor (ABS)	Noncarcinogen PRG HQ = 0.1 (mg/kg)	Noncarcinogen PRG HQ = 0.5 (mg/kg)	Noncarcinogen PRG HQ = 1 (mg/kg)
Arsenic	3.00E-04	2.85E-04	NA	1.50E+00	1.4E+00	1.51E+01	3.20E-02	1.4E+01	7.0E+01	1.4E+02
Benzo(a)anthracene	NA	NA	NA	7.30E-01	NA	NA	NA			
Benzo(a)pyrene	NA	NA	NA	7.30E+00	NA	3.10E+00	NA			
Benzo(b)fluoranthene	NA	NA	NA	7.30E-01	NA	NA	NA			
Benzo(k)fluoranthene	NA	NA	NA	7.30E-02	NA	NA	NA			
Dibenz(a,h)anthracene	NA	NA	NA	7.30E+00	NA	NA	NA			
Indeno(1,2,3-cd)pyrene	NA	NA	NA	7.30E-01	NA	NA	NA			

Noncarcinogenic calculations:

$$\text{Soil PRG (mg/kg)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn + Cn)}$$

An = $1/RfDo \times IRS/10^6$ mg/kg

Bn = $1/RfDd \times SSA \times AF \times ABS \times 1/10^6$ mg/kg

Cn = $1/RfDi \times IRA \times ET \times 1/PEF$

Carcinogen calculations:

$$\text{Soil PRG (mg/kg)} = \frac{TR \times BW \times AT_c}{EF \times ED \times (Ac + Bc + Cc)}$$

Ac = $CSFo \times IRS/10^6$ mg/kg

Bc = $CSFd \times SSA \times AF \times ABS \times 1/10^6$ mg/kg

Cc = $CSFi \times IRA \times ET \times 1/PEF$

EXPOSURE ASSUMPTIONS	
BW - Body Weight (kilograms)	70
ATnc - Averaging Time for Noncarcinogens (days)	9,125
ATc - Averaging Time for Carcinogens (days)	25,550
EF - Exposure Frequency (days/year)	350
ED - Exposure Duration (year)	24
ET - Exposure Time (hours/day)	24
IRS - Ingestion Rate (mg/day)	100
SSA - Skin Surface Area (cm^2)	5,800
AF - Soil to Skin Adherence Factor (mg/cm^2)	0.32
ABS - Absorption Factor (unitless)	chemical specific
IRA - Inhalation Rate (m^3/hour)	0.83
PEF - Particulate Emission Factor (m^3/kg)	1.32E+09

NA - No reference dose or slope factor available.

Exposure assumption values are those used for the SWMU 15 baseline human health risk assessment.

Table F-8
Preliminary Remediation Goals for Soil
Residential Child Scenario
NAS Oceana, SWMU 15

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDI) (mg/kg-day)	Oral Slope Factor (CSFo) (kg-day/mg)	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFi) (kg-day/mg)	Absorption Factor (ABS)	Noncarcinogen PRG HQ = 0.1 (mg/kg)	Noncarcinogen PRG HQ = 0.5 (mg/kg)	Noncarcinogen PRG HQ = 1 (mg/kg)
Arsenic	3.00E-04	2.85E-04	NA	1.50E+00	1.4E+00	1.51E+01	3.20E-02	2.1E+00	1.0E+01	2.1E+01
Benzo(a)anthracene	NA	NA	NA	7.30E-01	NA	NA	NA			
Benzo(a)pyrene	NA	NA	NA	7.30E+00	NA	3.10E+00	NA			
Benzo(b)fluoranthene	NA	NA	NA	7.30E-01	NA	NA	NA			
Benzo(k)fluoranthene	NA	NA	NA	7.30E-02	NA	NA	NA			
Dibenz(a,h)anthracene	NA	NA	NA	7.30E+00	NA	NA	NA			
Indeno(1,2,3-cd)pyrene	NA	NA	NA	7.30E-01	NA	NA	NA			

Noncarcinogenic calculations:

$$\text{Soil PRG (mg/kg)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn + Cn)}$$

An = $1/RfDo \times IRS/10^6$ mg/kg

Bn = $1/RfDd \times SSA \times AF \times ABS \times 1/10^6$ mg/kg

Cn = $1/RfDi \times IRA \times ET \times 1/PEF$

Carcinogen calculations:

$$\text{Soil PRG (mg/kg)} = \frac{TR \times BW \times AT_c}{EF \times ED \times (Ac + Bc + Cc)}$$

Ac = $CSFo \times IRS/10^6$ mg/kg

Bc = $CSFd \times SSA \times AF \times ABS \times 1/10^6$ mg/kg

Cc = $CSFi \times IRA \times ET \times 1/PEF$

EXPOSURE ASSUMPTIONS	
BW - Body Weight (kilograms)	15
ATnc - Averaging Time for Noncarcinogens (days)	2,190
ATc - Averaging Time for Carcinogens (days)	25,550
EF - Exposure Frequency (days/year)	350
ED - Exposure Duration (year)	6
ET - Exposure Time (hours/day)	24
IRS - Ingestion Rate (mg/day)	200
SSA - Skin Surface Area (cm^2)	2,379
AF - Soil to Skin Adherence Factor (mg/cm^2)	0.32
ABS - Absorption Factor (unitless)	chemical specific
IRA - Inhalation Rate (m^3/hour)	0.50
PEF - Particulate Emission Factor (m^3/kg)	1.32E+09

NA - No reference dose or slope factor available.

Exposure assumption values are those used for the SWMU 15 baseline human health risk assessment.

Table F-9
Preliminary Remediation Goals for Soil
Residential Adult/Child Scenario
NAS Oceana, SWMU 15

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDi) (mg/kg-day)	Oral Slope Factor (CSFo) (kg-day/mg)	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFi) (kg-day/mg)	Absorption Factor (ABS)	Carcinogen PRG Risk = 1E-06 (mg/kg)	Carcinogen PRG Risk = 1E-05 (mg/kg)	Carcinogen PRG Risk = 1E-04 (mg/kg)
Arsenic	3.00E-04	2.85E-04	NA	1.50E+00	1.4E+00	1.51E+01	3.20E-02	3.4E-01	3.4E+00	3.4E+01
Benzo(a)anthracene	NA	NA	NA	7.30E-01	NA	NA	NA	8.7E-01	8.7E+00	8.7E+01
Benzo(a)pyrene	NA	NA	NA	7.30E+00	NA	3.10E+00	NA	8.7E-02	8.7E-01	8.7E+00
Benzo(b)fluoranthene	NA	NA	NA	7.30E-01	NA	NA	NA	8.7E-01	8.7E+00	8.7E+01
Benzo(k)fluoranthene	NA	NA	NA	7.30E-02	NA	NA	NA	8.7E+00	8.7E+01	8.7E+02
Dibenz(a,h)anthracene	NA	NA	NA	7.30E+00	NA	NA	NA	8.7E-02	8.7E-01	8.7E+00
Indeno(1,2,3-cd)pyrene	NA	NA	NA	7.30E-01	NA	NA	NA	8.7E-01	8.7E+00	8.7E+01

Carcinogen calculations:

$$\text{Soil PRG (mg/kg)} = \frac{TR \times AT_c}{EF \times (Ac + Bc + Cc)}$$

Ac = $CSFo \times IRSadj/10^6$ mg/kg

Bc = $CSFd \times SSAadj \times AF \times ABS \times 1/10^6$ mg/kg

Cc = $CSFi \times IRAadj \times ET \times 1/PEF$

EXPOSURE ASSUMPTIONS	Adult	Child	Age-Adjusted
BW - Body Weight (kilograms)	70	15	
ATnc - Averaging Time for Noncarcinogens (days)	9,125	2,190	
ATc - Averaging Time for Carcinogens (days)	25,550	25,550	
EF - Exposure Frequency (days/year)	350	350	
ED - Exposure Duration (year)	24	6	
ET - Exposure Time (hours/day)	24	24	
IRS - Ingestion Rate (mg/day)	100	200	114
SSA - Skin Surface Area (cm^2)	5,800	2,379	2,940
AF - Soil to Skin Adherence Factor (mg/cm^2)	0.32	0.32	
ABS - Absorption Factor (unitless)	chemical specific	chemical specific	
IRA - Inhalation Rate (m^3/hour)	0.83	0.50	11.63
PEF - Particulate Emission Factor (m^3/kg)	1.32E+09	1.32E+09	

NA - No reference dose or slope factor available.

Exposure assumption values are those used for the SWMU 15 baseline human health risk assessment.

Table F-10
Preliminary Remediation Goals
Groundwater
Adult Residential Scenario
SWMU 24, NAS Oceana

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDi) (mg/kg-day)	Target Organ	DAevent (L/cm²-day)	Shower Exposure (L/day)	Noncarcinogen Groundwater PRG HQ = 0.1 (mg/L)	Noncarcinogen Groundwater PRG HQ = 0.5 (mg/L)	Noncarcinogen Groundwater PRG HQ = 1 (mg/L)	Noncarcinogen PRG PRG (mg/kg)	Noncarcinogen PRG Target HQ[1] (mg/kg)
VOCs											
cis-1,2-Dichloroethene	1.00E-02	8.00E-03	NA	blood	7.2E-06	6.1E-03	3.3E-02	1.7E-01	3.3E-01	1.7E-01	0.50
Inorganics											
Arsenic	3.00E-04	2.85E-04	NA	skin, vascular	2.0E-07		1.1E-03	5.5E-03	1.1E-02	1.1E-02	1
Iron	3.00E-01	6.00E-02	NA	GI, blood, liver	2.0E-07		1.1E+00	5.4E+00	1.1E+01	5.4E+00	0.50
Manganese	2.00E-02	7.00E-03	1.43E-05	CNS	2.0E-07		7.3E-02	3.6E-01	7.3E-01	7.3E-01	1

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn + Cn)}$$

An = 1/RfDo x IR

Bn = 1/RfDd x SA x DAevent

Cn = 1/RfDi x Shower Exposure

EXPOSURE ASSUMPTIONS	
BW - Body weight (kilograms)	70
ATnc - Averaging time for noncarcinogens (days)	8,760
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	24
IR - Ingestion rate (L/day)	2
SA - Skin surface area (cm²)	20,000

NA - No reference dose or slope factor available.

1 Applicable HQ calculated so that total HQ for a target organ does not exceed 1.

Table F-10a
Calculation of DAevent
Groundwater, Adult
SWMU 24, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t* (hr)	B (dimensionless)	DAevent (L/cm^2-day)	Eq
cis-1,2-Dichloroethene[1]	1.0E-02	3.4E-01	2.0E-01	8.2E-01	7.3E-03	7.2E-06	2
Arsenic	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1
Iron	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1
Manganese	1.0E-03	N/A	2.0E-01	N/A	N/A	2.0E-07	1

Inorganics: DAevent (mg/cm2-event) =

PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: *DAevent (mg/cm2-event)* =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.
[1] trans-1,2-Dichloroethene used as a surrogate.

Table F-10b
Inhalation Exposure Concentrations from Foster and Chrostowski Shower Model
SWMU 24, NAS Oceana

Chemical	Molecular weight (MW) (g/mole)	Henry's Law Constant (H) (atm-m^3/mole)	Kg (VOC) (cm/hr)	Kl(VOC) (cm/hr)	KL (cm/hr)	Kal (cm/hr)	Cwd	S (L/m^3-min)	Inhalation Exposure (InExp) (L/kg-shower)	Shower Exposure (InExp X BW) (L/day)
cis-1,2-Dichloroethene	97	7.6E-03	1.3E+03	1.3E+01	1.3E+01	1.8E+01	4.4E-01	3.0E+00	8.7E-05	6.1E-03

Variables	Units	Exposure Assumptions
Kg(VOC) = gas-film mass transfer coefficient	cm/hr	Solved by Eq 1
Kl(VOC) = liquid-film mass transfer coefficient	cm/hr	Solved by Eq 2
KL = overall mass transfer coefficient	cm/hr	Solved by Eq 3
Kal = adjusted overall mass transfer coeff.	cm/hr	Solved by Eq 4
Tl = Calibration temp. of water	K (20C +273)	293
Ts = Shower water temperature	k (45C)	318
Us = water viscosity at Ts	centipoise	0.596
Ul = water viscosity at Tl	cp	1.002
Cwd = conc. leaving droplets after time sdt		Solved by Eq 5
sdt = shower droplet drop time	sec	2
d = shower droplet diameter	mm	1
FR = shower water flow rate	l/min	20
SV = shower room air volume	m^3	3
S = indoor VOC generation rate	L/m^3-min	Solved by Eq 6
VR = ventilation rate	l/min	13.8
BW = body weight	kg	70
Ds = duration of shower	min	12
Dt = total duration in shower room	min	20
R = air exchange rate	min^{-1}	0.0167
Ca = indoor air concentration of VOCs	L-ug/mg-m^3	Solved by Eq 7
Einh = inhalation exposure per shower	L/kg-shower	Solved by Eq 8

Equation 1:	Kg(VOC) =	$3000 * (18 / MW)^{0.5}$	
Equation 2:	Kl(VOC) =	$20 * (44 / MW)^{0.5}$	
Equation 3:	KL =	$((1 / Kl(VOC)) + (0.024 / (Kg(VOC) * H)))^{-1}$	
Equation 4:	Kal =	$(KL * (((Tl * Us) / (Ts * Ul))^{-0.5}))$	
Equation 5:	Cwd =	((1-EXP((-1 * Kal * sdt)/(60 * d))))	
Equation 6:	S =	(Cwd * FR / SV)	
Equation 7:	see time series example on Table I-GW-6		
Equation 8:	Einh =	If t>Ds	(((VR * S) / (BW * R * 1000000)) * ((Ds + (EXP(-R * Dt) / R)-(EXP(R * (Ds - Dt))) / R)))

Table F-11
Preliminary Remediation Goals
Groundwater
Child Residential Scenario
SWMU 24, NAS Oceana

Chemical	Chronic Oral RfD (RfDo) (mg/kg-day)	Chronic Dermal RfD (RfDd) (mg/kg-day)	Chronic Inhalation RfD (RfDi) (mg/kg-day)	Target Organ	DAevent (L/cm^2-day)	Noncarcinogen Groundwater PRG HQ = 0.1 (mg/L)	HQ = 0.5 (mg/L)	HQ = 1 (mg/L)	Noncarcinogen PRG PRG (mg/L)	Target HQ[1]
VOCs			NA							
cis-1,2-Dichloroethene	1.00E-02	8.00E-03	NA	blood	9.3E-06	1.4E-02	7.2E-02	1.4E-01	7.2E-02	0.50
Inorganics										
Arsenic	3.00E-04	2.85E-04	NA	skin, vascular	3.3E-07	4.7E-04	2.3E-03	4.7E-03	4.7E-03	1.00
Iron	3.00E-01	6.00E-02	NA	GI, blood, liver	3.3E-07	4.6E-01	2.3E+00	4.6E+00	2.3E+00	0.50
Manganese	2.00E-02	7.00E-03	1.43E-05	CNS	3.3E-07	3.1E-02	1.6E-01	3.1E-01	3.1E-01	1.00

Noncarcinogenic calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{THQ \times BW \times AT_n}{EF \times ED \times (An + Bn)}$$

An = $1/RfDo \times IR$

Bn = $1/RfDd \times SA \times DAevent$

EXPOSURE ASSUMPTIONS	
BW - Body weight (kilograms)	15
ATnc - Averaging time for noncarcinogens (days)	2,190
ATc - Averaging time for carcinogens (days)	25,550
EF - Exposure frequency (days/year)	350
ED - Exposure duration (year)	6
IR - Ingestion rate (L/day)	1
SA - Skin surface area (cm^2)	7,930

NA - No reference dose or slope factor available.

1 Applicable HQ calculated so that total HQ for a target organ does not exceed 1.

Table F-11a
Calculation of DAevent
Groundwater, Child
SWMU 24, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ET) (hr)	t* (hr)	B (dimensionless)	DAevent (L/cm^2-day)	Eq
cis-1,2-Dichloroethene[1]	1.0E-02	3.4E-01	3.3E-01	8.2E-01	7.3E-03	9.3E-06	2
Arsenic	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Iron	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1
Manganese	1.0E-03	N/A	3.3E-01	N/A	N/A	3.3E-07	1

Inorganics: DAevent (mg/cm2-event) =

PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.
[1] trans-1,2-Dichloroethene used as a surrogate.

Table F-12
Preliminary Remediation Goals
Groundwater
Lifetime Residential Scenario
SWMU 24, NAS Oceana

Chemical	Oral Slope Factor (CSFo) (kg-day/mg)	Dermal Slope Factor (CSFd) (kg-day/mg)	Inhalation Slope Factor (CSFi) (kg-day/mg)	DAevent-a (L/cm^2-day)	DAevent-c (L/cm^2-day)	Shower Exposure (L/day)	Carcinogen PRG Risk = 1E-06 (mg/L)	Carcinogen PRG Risk = 1E-05 (mg/L)	Carcinogen PRG Risk = 1E-04 (mg/L)
VOCs									
cis-1,2-Dichloroethene	NA	NA	NA	7.2E-06	9.3E-06				
Inorganics									
Arsenic	1.50E+00	1.6E+00	1.51E+01	2.0E-07	3.3E-07		4.5E-05	4.5E-04	4.5E-03
Iron	NA	NA	NA	2.0E-07	3.3E-07				
Manganese	NA	NA	NA	2.0E-07	3.3E-07				

Carcinogen calculations:

$$\text{Groundwater RBC (mg/L)} = \frac{TR \times AT_c}{EF \times (Ac + Bc + Cc)}$$

Ac = CSFo x IRadj

Bc = CSFd x [(SAa x DAevent-a x EDa)/BWa + (SAc x DAevent-c X EDc)/BWc]

Cc = CSFi x Shower Exposure x EDa x 1/BWa

EXPOSURE ASSUMPTIONS	Lifetime	Adult (a)	Child (c)
BW - Body weight (kilograms)		70	15
ATnc - Averaging time for noncarcinogens (days)		8,760	2,190
ATc - Averaging time for carcinogens (days)		25,550	25,550
EF - Exposure frequency (days/year)		350	350
ED - Exposure duration (year)		24	6
IR - Ingestion rate (L/day)		2	1
IRdj - Ingestion rate (L-year/kg-day)	1.09		
SA - Skin surface area (cm^2)		20,000	7,930
ET - Exposure Time (hours/day)		0.20	0.33

NA - No reference dose or slope factor available.

Table F-12a
Calculation of DAevent
Groundwater, Child/Adult
SWMU 24, NAS Oceana

Chemical of Potential Concern	Permeability Constant (PC) (cm/hr)	Lag Time (t) (hr)	Duration of Event (ETa) (hr)	Duration of Event (ETc) (hr)	t* (hr)	B (dimensionless)	Daevent Adult (L/cm^2-day)	Daevent Child (L/cm^2-day)	Eq
cis-1,2-Dichloroethene[1]	1.0E-02	3.4E-01	2.0E-01	3.3E-01	8.2E-01	7.3E-03	7.2E-06	9.3E-06	2
Arsenic	1.0E-03	N/A	2.0E-01	3.3E-01	N/A	N/A	2.0E-07	3.3E-07	1
Iron	1.0E-03	N/A	2.0E-01	3.3E-01	N/A	N/A	2.0E-07	3.3E-07	1
Manganese	1.0E-03	N/A	2.0E-01	3.3E-01	N/A	N/A	2.0E-07	3.3E-07	1

Inorganics: DAevent (mg/cm2-event) =
PC x ET x CF2 (eq 1)

Organics: DAevent (mg/cm2-event) =

ET<t*: DAevent (mg/cm2-event) =
2 x PC x (sqrt((6 x t x ET)/3.1415))
x CF2 (eq 2)

Permeability constants from EPA 1992, Dermal Exposure Assessment: Principals and Applications.
ORD, EPA/600/8-91/001B. Default value of 0.001 cm/hour used for inorganics without published values.
N/A - not applicable.
[1] trans-1,2-Dichloroethene used as a surrogate.

Appendix G
Preliminary Cost Estimates

Estimate Summary

PROJECT: Feasibility Study (Groundwater)
SITE: Oceana SWMU 1, Virginia Beach, VA
ALTERNATIVE 1
DESCRIPTION: No Action

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	TOTAL
5-year Site Reviews*					
Visual Site Inspection	1	LS	$1,980	$1,980	$1,980
GRAND TOTAL ANNUAL					$2,000
PRESENT WORTH				$6,500	

*Contingency and Overhead & Profit are built into the unit cost.
The 5-year site review includes a one-day visual site inspection.

Alternative 1 - No Action

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000			$ -	$ -	$ -	$ -
1	2002	0.960			$ -	$ -	$ -	$ -
2	2003	0.921			$ -	$ -	$ -	$ -
3	2004	0.884			$ -	$ -	$ -	$ -
4	2005	0.848		$ 2,000	$ 2,000	$ -	$ 1,697	$ 1,697
5	2006	0.814			$ -	$ -	$ -	$ -
6	2007	0.781			$ -	$ -	$ -	$ -
7	2008	0.750			$ -	$ -	$ -	$ -
8	2009	0.720			$ -	$ -	$ -	$ -
9	2010	0.691		$ 2,000	$ 2,000	$ -	$ 1,381	$ 1,381
10	2011	0.663			$ -	$ -	$ -	$ -
11	2012	0.636			$ -	$ -	$ -	$ -
12	2013	0.610			$ -	$ -	$ -	$ -
13	2014	0.586			$ -	$ -	$ -	$ -
14	2015	0.562		$ 2,000	$ 2,000	$ -	$ 1,124	$ 1,124
15	2016	0.539			$ -	$ -	$ -	$ -
16	2017	0.518			$ -	$ -	$ -	$ -
17	2018	0.497			$ -	$ -	$ -	$ -
18	2019	0.477			$ -	$ -	$ -	$ -
19	2020	0.458		$ 2,000	$ 2,000	$ -	$ 915	$ 915
20	2021	0.439			$ -	$ -	$ -	$ -
21	2022	0.421			$ -	$ -	$ -	$ -
22	2023	0.404			$ -	$ -	$ -	$ -
23	2024	0.388			$ -	$ -	$ -	$ -
24	2025	0.373		$ 2,000	$ 2,000	$ -	$ 745	$ 745
25	2026	0.358			$ -	$ -	$ -	$ -
26	2027	0.343			$ -	$ -	$ -	$ -
27	2028	0.329			$ -	$ -	$ -	$ -
28	2029	0.316			$ -	$ -	$ -	$ -
29	2030	0.303		$ 2,000	$ 2,000	$ -	$ 607	$ 607
Total Alt 1			$ -	$ 12,000	$ 12,000	$ -	$ 6,469	$ 6,469

Estimate Summary

PROJECT: Feasibility Study (Groundwater)
SITE: Oceana SWMU 1, Virginia Beach, VA
ALTERNATIVE 2
DESCRIPTION: Free-product Removal, Institutional Controls, and Long-Term Monitoring

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 15.00%	OH&P 15.00%	TOTAL
LONG-TERM MONITORING							
Preparation of a Long-term Monitoring Plan	1	LS	$30,000	$30,000	$4,500	$5,175	$39,675
FIRST YEAR GROUNDWATER SAMPLING/ANALYSIS							
Quarterly Sampling/Analysis of 17 Existing Wells	1	LS	$163,388	$163,388	$24,508	$28,184	$216,081
First Year Groundwater Monitoring Technical Memorandum	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL CAPITAL							$282,300
Long-Term Monitoring							
Annual Sampling/Analysis of Existing 17 Wells	1	LS	$40,847	$40,847	$6,127	$7,046	$54,020
Long-term Monitoring Reporting	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL ANNUAL							$80,500
PRESENT WORTH				$1,617,700			

Free-product removal is presently currently occuring at SWMU 1, and will continue under this alternative. Due to this, the cost for free-product removal is not included in the present worth cost for this alternative.

Additonally, it is assumed that there is no cost associated with the implementation of institutional controls.

For long-term monitoring reporting, a comprehensive report will be prodcued after the 5th quarter sampling event and after the 5th year sampling event. During the 2nd, 3rd, and 4th years, streamlined reports will be prodcued. However, for cost estimating purposes, one level of effort was assumed for "reporting".

Alternative 2 - Free-product Removal, Institutional Controls, and Long-Term Monitoring

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000	$ 282,300		$ 282,300	$ 282,300	$ -	$ 282,300
1	2002	0.960		$ 80,500	$ 80,500	$ -	$ 77,255	$ 77,255
2	2003	0.921		$ 80,500	$ 80,500	$ -	$ 74,141	$ 74,141
3	2004	0.884		$ 80,500	$ 80,500	$ -	$ 71,153	$ 71,153
4	2005	0.848		$ 80,500	$ 80,500	$ -	$ 68,285	$ 68,285
5	2006	0.814		$ 80,500	$ 80,500	$ -	$ 65,533	$ 65,533
6	2007	0.781		$ 80,500	$ 80,500	$ -	$ 62,891	$ 62,891
7	2008	0.750		$ 80,500	$ 80,500	$ -	$ 60,356	$ 60,356
8	2009	0.720		$ 80,500	$ 80,500	$ -	$ 57,923	$ 57,923
9	2010	0.691		$ 80,500	$ 80,500	$ -	$ 55,589	$ 55,589
10	2011	0.663		$ 80,500	$ 80,500	$ -	$ 53,348	$ 53,348
11	2012	0.636		$ 80,500	$ 80,500	$ -	$ 51,198	$ 51,198
12	2013	0.610		$ 80,500	$ 80,500	$ -	$ 49,134	$ 49,134
13	2014	0.586		$ 80,500	$ 80,500	$ -	$ 47,154	$ 47,154
14	2015	0.562		$ 80,500	$ 80,500	$ -	$ 45,253	$ 45,253
15	2016	0.539		$ 80,500	$ 80,500	$ -	$ 43,429	$ 43,429
16	2017	0.518		$ 80,500	$ 80,500	$ -	$ 41,679	$ 41,679
17	2018	0.497		$ 80,500	$ 80,500	$ -	$ 39,999	$ 39,999
18	2019	0.477		$ 80,500	$ 80,500	$ -	$ 38,386	$ 38,386
19	2020	0.458		$ 80,500	$ 80,500	$ -	$ 36,839	$ 36,839
20	2021	0.439		$ 80,500	$ 80,500	$ -	$ 35,354	$ 35,354
21	2022	0.421		$ 80,500	$ 80,500	$ -	$ 33,929	$ 33,929
22	2023	0.404		$ 80,500	$ 80,500	$ -	$ 32,562	$ 32,562
23	2024	0.388		$ 80,500	$ 80,500	$ -	$ 31,249	$ 31,249
24	2025	0.373		$ 80,500	$ 80,500	$ -	$ 29,990	$ 29,990
25	2026	0.358		$ 80,500	$ 80,500	$ -	$ 28,781	$ 28,781
26	2027	0.343		$ 80,500	$ 80,500	$ -	$ 27,621	$ 27,621
27	2028	0.329		$ 80,500	$ 80,500	$ -	$ 26,507	$ 26,507
28	2029	0.316		$ 80,500	$ 80,500	$ -	$ 25,439	$ 25,439
29	2030	0.303		$ 80,500	$ 80,500	$ -	$ 24,414	$ 24,414
Total Alt 2			$ 282,300	$ 2,334,500	$ 2,616,800	$ 282,300	$ 1,335,390	$ 1,617,690

Estimate Summary

PROJECT: Feasibility Study (Groundwater)
SITE: Oceana SWMU 1, Virginia Beach, VA
ALTERNATIVE 3
DESCRIPTION: Use of ORC, Free-product Removal, Institutional Controls, and Long-Term Monitoring

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 15.00%	OH&P 15.00%	TOTAL
ORC/LONG-TERM MONITORING							
Preparation of a Long-term Monitoring/ORC Injection Plan	1	LS	$40,000	$40,000	$6,000	$6,900	$52,900
ORC PILOT STUDY							
Installation and Surveying of Four New Monitoring Wells	1	LS	$22,882	$22,882	$3,432	$3,947	$30,261
Pilot Study	1	LS	$6,660	$6,660	$999	$1,149	$8,808
Monitoring During Pilot Study	1	LS	$171,128	$171,128	$25,669	$29,520	$226,317
GRAND TOTAL CAPITAL							$318,300
FIRST YEAR ORC INJECTION							
ORC Injection	1	LS	$66,455	$66,455	$9,968	$11,463	$87,887
Monitoring	1	LS	$132,988	$132,988	$19,948	$22,940	$175,877
SECOND YEAR ORC INJECTION							
ORC Injection	1	LS	$53,164	$53,164	$7,975	$9,171	$70,309
Monitoring	1	LS	$33,247	$33,247	$4,987	$5,735	$43,969
THIRD YEAR ORC INJECTION							
ORC Injection	1	LS	$39,873	$39,873	$5,981	$6,878	$52,732
Monitoring	1	LS	$33,247	$33,247	$4,987	$5,735	$43,969
FIRST YEAR LONG-TERM MONITORING							
Quarterly Sampling/Analysis of Existing 17 and 4 New Wells	1	LS	$173,584	$173,584	$26,038	$29,943	$229,565
First Year Groundwater Monitoring Technical Memorandum	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
ANNUAL LONG-TERM MONITORING							
Long-Term Monitoring							
Annual Sampling/Analysis of Existing 17 and 4 New Wells	1	LS	$43,396	$43,396	$6,509	$7,486	$57,391
Long-term Monitoring Reporting	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL ANNUAL							$83,900

PRESENT WORTH	$2,067,300

Free-product removal is presently currently occuring at SWMU 1, and will continue under this alternative. Due to this, the cost for free-product removal is not included in the present worth cost for this alternative.

Additonally, it is assumed that there is no cost associated with the implementation of institutional controls.

It is assumed that long-term monitoring will still need to be conducted (assumes PRG will not bet met only from ORC application). For long-term monitoring reporting, a comprehensive report will be prodcued after the 5th quarter sampling event and after the 5th year sampling event. During the 2nd, 3rd, and 4th years, streamlined reports will be prodcued. However, for cost estimating purposes, one level of effort was assumed for "reporting".

Alternative 3 - Free-Product Removal, Use of ORC, Institutional Controls, and Long-Term Monitoring

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000	$ 318,300		$ 318,300	$ 318,300	$ -	$ 318,300
1	2002	0.960		$ 263,763	$ 263,763	$ -	$ 253,132	$ 253,132
2	2003	0.921		$ 114,279	$ 114,279	$ -	$ 105,252	$ 105,252
3	2004	0.884		$ 96,701	$ 96,701	$ -	$ 85,473	$ 85,473
4	2005	0.848		$ 256,015	$ 256,015	$ -	$ 217,167	$ 217,167
5	2006	0.814		$ 83,841	$ 83,841	$ -	$ 68,253	$ 68,253
6	2007	0.781		$ 83,841	$ 83,841	$ -	$ 65,501	$ 65,501
7	2008	0.750		$ 83,841	$ 83,841	$ -	$ 62,861	$ 62,861
8	2009	0.720		$ 83,841	$ 83,841	$ -	$ 60,328	$ 60,328
9	2010	0.691		$ 83,841	$ 83,841	$ -	$ 57,896	$ 57,896
10	2011	0.663		$ 83,841	$ 83,841	$ -	$ 55,562	$ 55,562
11	2012	0.636		$ 83,841	$ 83,841	$ -	$ 53,323	$ 53,323
12	2013	0.610		$ 83,841	$ 83,841	$ -	$ 51,173	$ 51,173
13	2014	0.586		$ 83,841	$ 83,841	$ -	$ 49,111	$ 49,111
14	2015	0.562		$ 83,841	$ 83,841	$ -	$ 47,131	$ 47,131
15	2016	0.539		$ 83,841	$ 83,841	$ -	$ 45,232	$ 45,232
16	2017	0.518		$ 83,841	$ 83,841	$ -	$ 43,408	$ 43,408
17	2018	0.497		$ 83,841	$ 83,841	$ -	$ 41,659	$ 41,659
18	2019	0.477		$ 83,841	$ 83,841	$ -	$ 39,980	$ 39,980
19	2020	0.458		$ 83,841	$ 83,841	$ -	$ 38,368	$ 38,368
20	2021	0.439		$ 83,841	$ 83,841	$ -	$ 36,822	$ 36,822
21	2022	0.421		$ 83,841	$ 83,841	$ -	$ 35,337	$ 35,337
22	2023	0.404		$ 83,841	$ 83,841	$ -	$ 33,913	$ 33,913
23	2024	0.388		$ 83,841	$ 83,841	$ -	$ 32,546	$ 32,546
24	2025	0.373		$ 83,841	$ 83,841	$ -	$ 31,234	$ 31,234
25	2026	0.358		$ 83,841	$ 83,841	$ -	$ 29,975	$ 29,975
26	2027	0.343		$ 83,841	$ 83,841	$ -	$ 28,767	$ 28,767
27	2028	0.329		$ 83,841	$ 83,841	$ -	$ 27,608	$ 27,608
28	2029	0.316		$ 83,841	$ 83,841	$ -	$ 26,495	$ 26,495
29	2030	0.303		$ 83,841	$ 83,841	$ -	$ 25,427	$ 25,427
Total Alt 3			$ 318,300	$ 2,826,788	$ 3,145,088	$ 318,300	$ 1,748,934	$ 2,067,234

Estimate Summary

PROJECT: Feasibility Study (Groundwater and Soil)
SITE: Oceana SWMU 15, Virginia Beach, VA
ALTERNATIVE 1
DESCRIPTION: No Action

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	TOTAL
5-year Site Reviews*					
Visual Site Inspection	1	LS	$1,980	$1,980	$1,980
GRAND TOTAL ANNUAL					$2,000
PRESENT WORTH				$6,500	

*Contingency and Overhead & Profit are built into the unit cost.

Alternative 1 - No Action

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000			$ -	$ -	$ -	$ -
1	2002	0.960			$ -	$ -	$ -	$ -
2	2003	0.921			$ -	$ -	$ -	$ -
3	2004	0.884			$ -	$ -	$ -	$ -
4	2005	0.848		$ 2,000	$ 2,000	$ -	$ 1,697	$ 1,697
5	2006	0.814			$ -	$ -	$ -	$ -
6	2007	0.781			$ -	$ -	$ -	$ -
7	2008	0.750			$ -	$ -	$ -	$ -
8	2009	0.720			$ -	$ -	$ -	$ -
9	2010	0.691		$ 2,000	$ 2,000	$ -	$ 1,381	$ 1,381
10	2011	0.663			$ -	$ -	$ -	$ -
11	2012	0.636			$ -	$ -	$ -	$ -
12	2013	0.610			$ -	$ -	$ -	$ -
13	2014	0.586			$ -	$ -	$ -	$ -
14	2015	0.562		$ 2,000	$ 2,000	$ -	$ 1,124	$ 1,124
15	2016	0.539			$ -	$ -	$ -	$ -
16	2017	0.518			$ -	$ -	$ -	$ -
17	2018	0.497			$ -	$ -	$ -	$ -
18	2019	0.477			$ -	$ -	$ -	$ -
19	2020	0.458		$ 2,000	$ 2,000	$ -	$ 915	$ 915
20	2021	0.439			$ -	$ -	$ -	$ -
21	2022	0.421			$ -	$ -	$ -	$ -
22	2023	0.404			$ -	$ -	$ -	$ -
23	2024	0.388			$ -	$ -	$ -	$ -
24	2025	0.373		$ 2,000	$ 2,000	$ -	$ 745	$ 745
25	2026	0.358			$ -	$ -	$ -	$ -
26	2027	0.343			$ -	$ -	$ -	$ -
27	2028	0.329			$ -	$ -	$ -	$ -
28	2029	0.316			$ -	$ -	$ -	$ -
29	2030	0.303		$ 2,000	$ 2,000	$ -	$ 607	$ 607
Total Atl 1			$ -	$ 12,000	$ 12,000	$ -	$ 6,469	$ 6,469

Estimate Summary

PROJECT: Feasibility Study (Groundwater and Soil)
SITE: Oceana SWMU 15, Virginia Beach, VA
ALTERNATIVE 2
DESCRIPTION: Monitored Natural Attenuation, Institutional Controls, In-situ Soil Landfarming

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNIT$	INSTALLED COSTS AMOUNT	CONTINGENCY 15.00%	OH&P 15.00%	TOTAL
MONITORED NATURAL ATTENUATION							
Preparation of a Monitored Natural Attenuation Plan	1	LS	$30,000	$30,000	$4,500	$5,175	$39,675
Installation and Surveying of Fifteen New Monitoring Wells	1	LS	$9,900	$9,900	$1,485	$1,708	$13,093
Soil MIP Investigation/Sampling and Analysis	1	LS	$23,548	$23,548	$3,532	$4,062	$31,142
MNA EVALUATION/GROUNDWATER MODELING							
Monitored Natural Attenuation Evaluation	1	LS	$25,000	$25,000	$3,750	$4,313	$33,063
IN-SITU LANDFARMING							
Tilling of the Soil and Confirmatory Sampling (Twice)	1	LS	$23,892	$23,892	$3,584	$4,121	$31,597
GRAND TOTAL CAPITAL							$148,600
Monitored Natural Attenuation							
Sampling /Analysis/Reporting of Fifteen New Wells	1	LS	$30,452	$30,452	$4,568	$5,253	$40,273
GRAND TOTAL ANNUAL							$71,900
PRESENT WORTH				$1,341,400			

It is assumed that there is no cost associated with the implementation of institutional controls.

Assumed will need to till the soil and collect confirmatory samples for a spring and fall season.

Alternative 2 - Monitored Natural Attenuation, Institutional Controls, In-situ Soil Landfarming

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000	$ 148,600		$ 148,600	$ 148,600	$ -	$ 148,600
1	2002	0.960		$ 71,900	$ 71,900	$ -	$ 69,002	$ 69,002
2	2003	0.921		$ 71,900	$ 71,900	$ -	$ 66,221	$ 66,221
3	2004	0.884		$ 71,900	$ 71,900	$ -	$ 63,551	$ 63,551
4	2005	0.848		$ 71,900	$ 71,900	$ -	$ 60,990	$ 60,990
5	2006	0.814		$ 71,900	$ 71,900	$ -	$ 58,532	$ 58,532
6	2007	0.781		$ 71,900	$ 71,900	$ -	$ 56,172	$ 56,172
7	2008	0.750		$ 71,900	$ 71,900	$ -	$ 53,908	$ 53,908
8	2009	0.720		$ 71,900	$ 71,900	$ -	$ 51,735	$ 51,735
9	2010	0.691		$ 71,900	$ 71,900	$ -	$ 49,650	$ 49,650
10	2011	0.663		$ 71,900	$ 71,900	$ -	$ 47,649	$ 47,649
11	2012	0.636		$ 71,900	$ 71,900	$ -	$ 45,728	$ 45,728
12	2013	0.610		$ 71,900	$ 71,900	$ -	$ 43,885	$ 43,885
13	2014	0.586		$ 71,900	$ 71,900	$ -	$ 42,116	$ 42,116
14	2015	0.562		$ 71,900	$ 71,900	$ -	$ 40,419	$ 40,419
15	2016	0.539		$ 71,900	$ 71,900	$ -	$ 38,789	$ 38,789
16	2017	0.518		$ 71,900	$ 71,900	$ -	$ 37,226	$ 37,226
17	2018	0.497		$ 71,900	$ 71,900	$ -	$ 35,725	$ 35,725
18	2019	0.477		$ 71,900	$ 71,900	$ -	$ 34,285	$ 34,285
19	2020	0.458		$ 71,900	$ 71,900	$ -	$ 32,904	$ 32,904
20	2021	0.439		$ 71,900	$ 71,900	$ -	$ 31,577	$ 31,577
21	2022	0.421		$ 71,900	$ 71,900	$ -	$ 30,304	$ 30,304
22	2023	0.404		$ 71,900	$ 71,900	$ -	$ 29,083	$ 29,083
23	2024	0.388		$ 71,900	$ 71,900	$ -	$ 27,911	$ 27,911
24	2025	0.373		$ 71,900	$ 71,900	$ -	$ 26,786	$ 26,786
25	2026	0.358		$ 71,900	$ 71,900	$ -	$ 25,706	$ 25,706
26	2027	0.343		$ 71,900	$ 71,900	$ -	$ 24,670	$ 24,670
27	2028	0.329		$ 71,900	$ 71,900	$ -	$ 23,676	$ 23,676
28	2029	0.316		$ 71,900	$ 71,900	$ -	$ 22,721	$ 22,721
29	2030	0.303		$ 71,900	$ 71,900	$ -	$ 21,805	$ 21,805
Total Alt 2			$ 148,600	$ 2,085,100	$ 2,233,700	$ 148,600	$ 1,192,727	$ 1,341,327

Estimate Summary

PROJECT:	Feasibility Study (Groundwater and Soil)
SITE:	Oceana SWMU 15, Virginia Beach, VA
ALTERNATIVE	3
DESCRIPTION:	Long Term Monitoring, Institutional Controls, In-situ Soil Landfarming

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 15.00%	OH&P 15.00%	TOTAL
LONG-TERM MONITORING							
Preparation of a Long-term Monitoring Plan	1	LS	$30,000	$30,000	$4,500	$5,175	$39,675
Installation and Surveying of Fifteen New Monitoring Wells	1	LS	$9,900	$9,900	$1,485	$1,708	$13,093
FIRST YEAR GROUNDWATER SAMPLING/ANALYSIS							
Quarterly Sampling/Analysis of Fifteen New Wells	1	LS	$148,364	$148,364	$22,255	$25,593	$196,211
First Year Groundwater Monitoring Technical Memorandum	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
IN-SITU LANDFARMING							
Tilling of the Soil and Confirmatory Sampling (Twice)	1	LS	$23,892	$23,892	$3,584	$4,121	$31,597
GRAND TOTAL CAPITAL							$307,000
Long-Term Monitoring							
Annual Sampling/Analysis of Fifteen New Groundwater Wells	1	LS	$37,091	$37,091	$5,564	$6,398	$49,053
Long-term Monitoring Reporting	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL ANNUAL							$75,600

PRESENT WORTH	$1,561,100

It is assumed that there is no cost associated with the implementation of institutional controls.

Assumed will need to till the soil and collect confirmatory samples for a spring and fall season.

For long-term monitoring reporting, a comprehensive report will be prodcued after the 5th quarter sampling event and after the 5th year sampling event. During the 2nd, 3rd, and 4th years, streamlined reports will be prodcued. However, for cost estimating purposes, one level of effort was assumed for "reporting".

Alternative 3 - Long Term Monitoring, Institutional Controls, In-situ Landfarming

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000	$ 307,000		$ 307,000	$ 307,000	$ -	$ 307,000
1	2002	0.960		$ 75,600	$ 75,600	$ -	$ 72,553	$ 72,553
2	2003	0.921		$ 75,600	$ 75,600	$ -	$ 69,628	$ 69,628
3	2004	0.884		$ 75,600	$ 75,600		$ 66,822	$ 66,822
4	2005	0.848		$ 75,600	$ 75,600	$ -	$ 64,128	$ 64,128
5	2006	0.814		$ 75,600	$ 75,600	$ -	$ 61,544	$ 61,544
6	2007	0.781		$ 75,600	$ 75,600	$ -	$ 59,063	$ 59,063
7	2008	0.750		$ 75,600	$ 75,600	$ -	$ 56,682	$ 56,682
8	2009	0.720		$ 75,600	$ 75,600	$ -	$ 54,398	$ 54,398
9	2010	0.691		$ 75,600	$ 75,600	$ -	$ 52,205	$ 52,205
10	2011	0.663		$ 75,600	$ 75,600	$ -	$ 50,101	$ 50,101
11	2012	0.636		$ 75,600	$ 75,600	$ -	$ 48,081	$ 48,081
12	2013	0.610		$ 75,600	$ 75,600	$ -	$ 46,143	$ 46,143
13	2014	0.586		$ 75,600	$ 75,600	$ -	$ 44,283	$ 44,283
14	2015	0.562		$ 75,600	$ 75,600	$ -	$ 42,499	$ 42,499
15	2016	0.539		$ 75,600	$ 75,600	$ -	$ 40,786	$ 40,786
16	2017	0.518		$ 75,600	$ 75,600	$ -	$ 39,142	$ 39,142
17	2018	0.497		$ 75,600	$ 75,600	$ -	$ 37,564	$ 37,564
18	2019	0.477		$ 75,600	$ 75,600	$ -	$ 36,050	$ 36,050
19	2020	0.458		$ 75,600	$ 75,600	$ -	$ 34,597	$ 34,597
20	2021	0.439		$ 75,600	$ 75,600	$ -	$ 33,202	$ 33,202
21	2022	0.421		$ 75,600	$ 75,600	$ -	$ 31,864	$ 31,864
22	2023	0.404		$ 75,600	$ 75,600	$ -	$ 30,580	$ 30,580
23	2024	0.388		$ 75,600	$ 75,600	$ -	$ 29,347	$ 29,347
24	2025	0.373		$ 75,600	$ 75,600	$ -	$ 28,164	$ 28,164
25	2026	0.358		$ 75,600	$ 75,600	$ -	$ 27,029	$ 27,029
26	2027	0.343		$ 75,600	$ 75,600	$ -	$ 25,939	$ 25,939
27	2028	0.329		$ 75,600	$ 75,600	$ -	$ 24,894	$ 24,894
28	2029	0.316		$ 75,600	$ 75,600	$ -	$ 23,891	$ 23,891
29	2030	0.303		$ 75,600	$ 75,600	$ -	$ 22,928	$ 22,928
Total Alt 3			$ 307,000	$ 2,192,400	$ 2,499,400	$ 307,000	$ 1,254,106	$ 1,561,106

Estimate Summary

PROJECT: Feasibility Study (Groundwater and Soil)
SITE: Oceana SWMU 15, Virginia Beach, VA
ALTERNATIVE 4
DESCRIPTION: Downgradient Reactive Curtain of ORC, Long-Term Monitoring, Institutional Controls, In-situ Soil Landfarming

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 15.00%	OH&P 15.00%	TOTAL
LONG-TERM MONITORING							
Preparation of a Long-term Monitoring Plan	1	LS	$30,000	$30,000	$4,500	$5,175	$39,675
Installation and Surveying of Fifteen New Monitoring Wells	1	LS	$9,900	$9,900	$1,485	$1,708	$13,093
FIRST YEAR GROUNDWATER SAMPLING/ANALYSIS							
Quarterly Sampling/Analysis of Fifteen New Wells	1	LS	$148,364	$148,364	$22,255	$25,593	$196,211
First Year Groundwater Monitoring Technical Memorandum	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
ORC INJECTION							
ORC Pilot Test	1	LS	$9,500	$9,500	$1,425	$1,639	$12,564
IN-SITU LANDFARMING							
Tilling of the Soil and Confirmatory Sampling (Twice)	1	LS	$23,892	$23,892	$3,584	$4,121	$31,597
GRAND TOTAL CAPITAL							$319,600
ORC Injection							
ORC Material Costs	1	LS	$6,200	$6,200	$930	$1,070	$8,200
ORC Injection Costs	1	LS	$11,000	$11,000	$1,650	$1,898	$14,548
Long-Term Monitoring							
Annual Sampling/Analysis of Fifteen New Groundwater Wells	1	LS	$37,091	$37,091	$5,564	$6,398	$49,053
Long-term Monitoring Reporting	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL ANNUAL							$98,200
PRESENT WORTH				$1,948,600			

It is assumed that there is no cost associated with the implementation of institutional controls.

Assumed will sample annually for a 30-year duration, and will re-inject ORC every nine months for a 30-year duration.

Assumed will need to till the soil and collect confirmatory samples for a spring and fall season.

It is assumed that long-term monitoring will still need to be conducted (assumes PRGs will not bet met only from ORC application).
For long-term monitoring reporting, a comprehensive report will be prodcued after the 5th quarter sampling event and after the 5th year sampling event. During the 2nd, 3rd, and 4th years, streamlined reports will be prodcued.
However, for cost estimating purposes, one level of effort was assumed for "reporting".

Alternative 4 - Downgradient Reactive Curtain of ORC, Long-Term Monitoring, Institutional Controls, In-situ Landfarming

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000	$ 319,600		$ 319,600	$ 319,600	$ -	$ 319,600
1	2002	0.960		$ 98,200	$ 98,200	$ -	$ 94,242	$ 94,242
2	2003	0.921		$ 98,200	$ 98,200	$ -	$ 90,443	$ 90,443
3	2004	0.884		$ 98,200	$ 98,200	$ -	$ 86,798	$ 86,798
4	2005	0.848		$ 98,200	$ 98,200	$ -	$ 83,299	$ 83,299
5	2006	0.814		$ 98,200	$ 98,200	$ -	$ 79,942	$ 79,942
6	2007	0.781		$ 98,200	$ 98,200	$ -	$ 76,719	$ 76,719
7	2008	0.750		$ 98,200	$ 98,200	$ -	$ 73,627	$ 73,627
8	2009	0.720		$ 98,200	$ 98,200	$ -	$ 70,659	$ 70,659
9	2010	0.691		$ 98,200	$ 98,200	$ -	$ 67,811	$ 67,811
10	2011	0.663		$ 98,200	$ 98,200	$ -	$ 65,078	$ 65,078
11	2012	0.636		$ 98,200	$ 98,200	$ -	$ 62,455	$ 62,455
12	2013	0.610		$ 98,200	$ 98,200	$ -	$ 59,938	$ 59,938
13	2014	0.586		$ 98,200	$ 98,200	$ -	$ 57,522	$ 57,522
14	2015	0.562		$ 98,200	$ 98,200	$ -	$ 55,203	$ 55,203
15	2016	0.539		$ 98,200	$ 98,200	$ -	$ 52,978	$ 52,978
16	2017	0.518		$ 98,200	$ 98,200	$ -	$ 50,843	$ 50,843
17	2018	0.497		$ 98,200	$ 98,200	$ -	$ 48,793	$ 48,793
18	2019	0.477		$ 98,200	$ 98,200	$ -	$ 46,827	$ 46,827
19	2020	0.458		$ 98,200	$ 98,200	$ -	$ 44,939	$ 44,939
20	2021	0.439		$ 98,200	$ 98,200	$ -	$ 43,128	$ 43,128
21	2022	0.421		$ 98,200	$ 98,200	$ -	$ 41,389	$ 41,389
22	2023	0.404		$ 98,200	$ 98,200	$ -	$ 39,721	$ 39,721
23	2024	0.388		$ 98,200	$ 98,200	$ -	$ 38,120	$ 38,120
24	2025	0.373		$ 98,200	$ 98,200	$ -	$ 36,584	$ 36,584
25	2026	0.358		$ 98,200	$ 98,200	$ -	$ 35,109	$ 35,109
26	2027	0.343		$ 98,200	$ 98,200	$ -	$ 33,694	$ 33,694
27	2028	0.329		$ 98,200	$ 98,200	$ -	$ 32,336	$ 32,336
28	2029	0.316		$ 98,200	$ 98,200	$ -	$ 31,032	$ 31,032
29	2030	0.303		$ 98,200	$ 98,200	$ -	$ 29,782	$ 29,782
Total Alt 4			$ 319,600	$ 2,847,800	$ 3,167,400	$ 319,600	$ 1,629,010	$ 1,948,610

Estimate Summary

PROJECT: Feasibility Study (Groundwater)
SITE: Oceana SWMU 24, Virginia Beach, VA
ALTERNATIVE 1
DESCRIPTION: No Action

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	TOTAL
5-year Site Reviews*					
Visual Site Inspection	1	LS	$1,980	$1,980	$1,980
GRAND TOTAL ANNUAL					$2,000
PRESENT WORTH				$6,500	

*Contingency and Overhead & Profit are built into the unit cost.

Alternative 1 - No Action

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000			$ -	$ -	$ -	$ -
1	2002	0.960			$ -	$ -	$ -	$ -
2	2003	0.921			$ -	$ -	$ -	$ -
3	2004	0.884			$ -	$ -	$ -	$ -
4	2005	0.848		$ 2,000	$ 2,000	$ -	$ 1,697	$ 1,697
5	2006	0.814			$ -	$ -	$ -	$ -
6	2007	0.781			$ -	$ -	$ -	$ -
7	2008	0.750			$ -	$ -	$ -	$ -
8	2009	0.720			$ -	$ -	$ -	$ -
9	2010	0.691		$ 2,000	$ 2,000	$ -	$ 1,381	$ 1,381
10	2011	0.663			$ -	$ -	$ -	$ -
11	2012	0.636			$ -	$ -	$ -	$ -
12	2013	0.610			$ -	$ -	$ -	$ -
13	2014	0.586			$ -	$ -	$ -	$ -
14	2015	0.562		$ 2,000	$ 2,000	$ -	$ 1,124	$ 1,124
15	2016	0.539			$ -	$ -	$ -	$ -
16	2017	0.518			$ -	$ -	$ -	$ -
17	2018	0.497			$ -	$ -	$ -	$ -
18	2019	0.477			$ -	$ -	$ -	$ -
19	2020	0.458		$ 2,000	$ 2,000	$ -	$ 915	$ 915
20	2021	0.439			$ -	$ -	$ -	$ -
21	2022	0.421			$ -	$ -	$ -	$ -
22	2023	0.404			$ -	$ -	$ -	$ -
23	2024	0.388			$ -	$ -	$ -	$ -
24	2025	0.373		$ 2,000	$ 2,000	$ -	$ 745	$ 745
25	2026	0.358			$ -	$ -	$ -	$ -
26	2027	0.343			$ -	$ -	$ -	$ -
27	2028	0.329			$ -	$ -	$ -	$ -
28	2029	0.316			$ -	$ -	$ -	$ -
29	2030	0.303		$ 2,000	$ 2,000	$ -	$ 607	$ 607
Total Alt 1			$ -	$ 12,000	$ 12,000	$ -	$ 6,469	$ 6,469

Estimate Summary

PROJECT: Feasibility Study (Groundwater)
SITE: Oceana SWMU 24, Virginia Beach, VA
ALTERNATIVE 2
DESCRIPTION: Institutional Controls and Long-Term Monitoring

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 15.00%	OH&P 15.00%	TOTAL
LONG-TERM MONITORING							
Preparation of a Long-term Monitoring Plan	1	LS	$30,000	$30,000	$4,500	$5,175	$39,675
Installation and Surveying of Two New Monitoring Wells	1	LS	$11,441	$11,441	$1,716	$1,974	$15,131
FIRST YEAR GROUNDWATER SAMPLING/ANALYSIS							
Quarterly Sampling/Analysis of Twelve Existing and Two New Wells	1	LS	$121,640	$121,640	$18,246	$20,983	$160,869
First Year Groundwater Monitoring Technical Memorandum	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL CAPITAL							$242,100
Long-Term Monitoring							
Annual Sampling/Analysis of Existing Twelve Existing and Two New Wells	1	LS	$30,410	$30,410	$4,562	$5,246	$40,217
Long-term Monitoring Reporting	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL ANNUAL							$66,700

PRESENT WORTH	$1,348,600

It is assumed that there is no cost associated with the implementation of institutional controls.

For long-term monitoring reporting, a comprehensive report will be prodcued after the 5th quarter sampling event and after the 5th year sampling event. During the 2nd, 3rd, and 4th years, streamlined reports will be prodcued. However, for cost estimating purposes, one level of effort was assumed for "reporting".

Alternative 2 - Institutional Controls and Long-Term Monitoring

		E	A	B	C=A+B	C*A	C*B	C*E
Year		*Discount Factor at 4.2%*	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000	$ 242,100		$ 242,100	$ 242,100	$ -	$ 242,100
1	2002	0.960		$ 66,700	$ 66,700	$ -	$ 64,012	$ 64,012
2	2003	0.921		$ 66,700	$ 66,700	$ -	$ 61,431	$ 61,431
3	2004	0.884		$ 66,700	$ 66,700	$ -	$ 58,955	$ 58,955
4	2005	0.848		$ 66,700	$ 66,700	$ -	$ 56,579	$ 56,579
5	2006	0.814		$ 66,700	$ 66,700	$ -	$ 54,298	$ 54,298
6	2007	0.781		$ 66,700	$ 66,700	$ -	$ 52,110	$ 52,110
7	2008	0.750		$ 66,700	$ 66,700	$ -	$ 50,009	$ 50,009
8	2009	0.720		$ 66,700	$ 66,700	$ -	$ 47,994	$ 47,994
9	2010	0.691		$ 66,700	$ 66,700	$ -	$ 46,059	$ 46,059
10	2011	0.663		$ 66,700	$ 66,700	$ -	$ 44,203	$ 44,203
11	2012	0.636		$ 66,700	$ 66,700	$ -	$ 42,421	$ 42,421
12	2013	0.610		$ 66,700	$ 66,700	$ -	$ 40,711	$ 40,711
13	2014	0.586		$ 66,700	$ 66,700	$ -	$ 39,070	$ 39,070
14	2015	0.562		$ 66,700	$ 66,700	$ -	$ 37,495	$ 37,495
15	2016	0.539		$ 66,700	$ 66,700	$ -	$ 35,984	$ 35,984
16	2017	0.518		$ 66,700	$ 66,700	$ -	$ 34,534	$ 34,534
17	2018	0.497		$ 66,700	$ 66,700	$ -	$ 33,142	$ 33,142
18	2019	0.477		$ 66,700	$ 66,700	$ -	$ 31,806	$ 31,806
19	2020	0.458		$ 66,700	$ 66,700	$ -	$ 30,524	$ 30,524
20	2021	0.439		$ 66,700	$ 66,700	$ -	$ 29,294	$ 29,294
21	2022	0.421		$ 66,700	$ 66,700	$ -	$ 28,113	$ 28,113
22	2023	0.404		$ 66,700	$ 66,700	$ -	$ 26,980	$ 26,980
23	2024	0.388		$ 66,700	$ 66,700	$ -	$ 25,892	$ 25,892
24	2025	0.373		$ 66,700	$ 66,700	$ -	$ 24,849	$ 24,849
25	2026	0.358		$ 66,700	$ 66,700	$ -	$ 23,847	$ 23,847
26	2027	0.343		$ 66,700	$ 66,700	$ -	$ 22,886	$ 22,886
27	2028	0.329		$ 66,700	$ 66,700	$ -	$ 21,963	$ 21,963
28	2029	0.316		$ 66,700	$ 66,700	$ -	$ 21,078	$ 21,078
29	2030	0.303		$ 66,700	$ 66,700	$ -	$ 20,228	$ 20,228
Total Alt 2			$ 242,100	$ 1,934,300	$ 2,176,400	$ 242,100	$ 1,106,466	$ 1,348,566

Estimate Summary

PROJECT: Feasibility Study (Groundwater)
SITE: Oceana SWMU 24, Virginia Beach, VA
ALTERNATIVE 3
DESCRIPTION: Use of ORC, Institutional Controls, and Long-Term Monitoring

DESCRIPTION	QTY	UNIT	INSTALLED COSTS UNITS	INSTALLED COSTS AMOUNT	CONTINGENCY 15.00%	OH&P 15.00%	TOTAL
ORC/LONG-TERM MONITORING							
Preparation of a Long-term Monitoring/ORC Injection Plan	1	LS	$40,000	$40,000	$6,000	$6,900	$52,900
ORC PILOT STUDY							
Installation and Surveying of Four New Monitoring Wells	1	LS	$22,882	$22,882	$3,432	$3,947	$30,261
Pilot Study	1	LS	$6,000	$6,000	$900	$1,035	$7,935
Monitoring During Pilot Study	1	LS	$180,904	$180,904	$27,136	$31,206	$239,246
GRAND TOTAL CAPITAL							$330,400
FIRST YEAR ORC INJECTION							
ORC Injection	1	LS	$34,110	$34,110	$5,117	$5,884	$45,110
Monitoring	1	LS	$124,000	$124,000	$18,600	$21,390	$163,990
SECOND YEAR ORC INJECTION							
ORC Injection	1	LS	$27,288	$27,288	$4,093	$4,707	$36,088
Monitoring	1	LS	$31,000	$31,000	$4,650	$5,348	$40,998
THIRD YEAR ORC INJECTION							
ORC Injection	1	LS	$20,466	$20,466	$3,070	$3,530	$27,066
Monitoring	1	LS	$31,000	$31,000	$4,650	$5,348	$40,998
FIRST YEAR LONG-TERM MONITORING							
Quarterly Sampling/Analysis of Twelve Existing and Four New Wells	1	LS	$121,640	$121,640	$18,246	$20,983	$160,869
First Year Groundwater Monitoring Technical Memorandum	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
ANNUAL LONG-TERM MONITORING							
Long-Term Monitoring							
Annual Sampling/Analysis of Existing Twelve Existing and Four New Wells	1	LS	$30,410	$30,410	$4,562	$5,246	$40,217
Long-term Monitoring Reporting	1	LS	$20,000	$20,000	$3,000	$3,450	$26,450
GRAND TOTAL ANNUAL							$66,700

PRESENT WORTH	$1,686,200

Free-product removal is presently currently occuring at SWMU 1, and will continue under this alternative. Due to this, the cost for free-product removal is not included in the present worth cost for this alternative.

Additonally, it is assumed that there is no cost associated with the implementation of institutional controls.

It is assumed that long-term monitoring will still need to be conducted (assumes PRG will not bet met only from ORC application). For long-term monitoring reporting, a comprehensive report will be prodcued after the 5th quarter sampling event and after the 5th year sampling event. During the 2nd, 3rd, and 4th years, streamlined reports will be prodcued.

Alternative 3 - Use of ORC, Institutional Controls, and Long-Term Monitoring

		E	A	B	C=A+B	C*A	C*B	C*E
Year		Discount Factor at 4.2%	Capital Cost	O&M Cost	Total Cost	Total PV Capital Costs at 4.2% ($)	Total PV O&M Costs at 4.2% ($)	Total PV Costs at 4.2% ($)
0	2001	1.000	$ 330,400		$ 330,400	$ 330,400	$ -	$ 330,400
1	2002	0.960		$ 209,100	$ 209,100	$ -	$ 200,672	$ 200,672
2	2003	0.921		$ 77,086	$ 77,086	$ -	$ 70,997	$ 70,997
3	2004	0.884		$ 68,064	$ 68,064	$ -	$ 60,161	$ 60,161
4	2005	0.848		$ 187,319	$ 187,319	$ -	$ 158,895	$ 158,895
5	2006	0.814		$ 66,667	$ 66,667	$ -	$ 54,272	$ 54,272
6	2007	0.781		$ 66,667	$ 66,667	$ -	$ 52,084	$ 52,084
7	2008	0.750		$ 66,667	$ 66,667	$ -	$ 49,985	$ 49,985
8	2009	0.720		$ 66,667	$ 66,667	$ -	$ 47,970	$ 47,970
9	2010	0.691		$ 66,667	$ 66,667	$ -	$ 46,037	$ 46,037
10	2011	0.663		$ 66,667	$ 66,667	$ -	$ 44,181	$ 44,181
11	2012	0.636		$ 66,667	$ 66,667	$ -	$ 42,400	$ 42,400
12	2013	0.610		$ 66,667	$ 66,667	$ -	$ 40,691	$ 40,691
13	2014	0.586		$ 66,667	$ 66,667	$ -	$ 39,051	$ 39,051
14	2015	0.562		$ 66,667	$ 66,667	$ -	$ 37,477	$ 37,477
15	2016	0.539		$ 66,667	$ 66,667	$ -	$ 35,966	$ 35,966
16	2017	0.518		$ 66,667	$ 66,667	$ -	$ 34,517	$ 34,517
17	2018	0.497		$ 66,667	$ 66,667	$ -	$ 33,125	$ 33,125
18	2019	0.477		$ 66,667	$ 66,667	$ -	$ 31,790	$ 31,790
19	2020	0.458		$ 66,667	$ 66,667	$ -	$ 30,509	$ 30,509
20	2021	0.439		$ 66,667	$ 66,667	$ -	$ 29,279	$ 29,279
21	2022	0.421		$ 66,667	$ 66,667	$ -	$ 28,099	$ 28,099
22	2023	0.404		$ 66,667	$ 66,667	$ -	$ 26,966	$ 26,966
23	2024	0.388		$ 66,667	$ 66,667	$ -	$ 25,879	$ 25,879
24	2025	0.373		$ 66,667	$ 66,667	$ -	$ 24,836	$ 24,836
25	2026	0.358		$ 66,667	$ 66,667	$ -	$ 23,835	$ 23,835
26	2027	0.343		$ 66,667	$ 66,667	$ -	$ 22,875	$ 22,875
27	2028	0.329		$ 66,667	$ 66,667	$ -	$ 21,952	$ 21,952
28	2029	0.316		$ 66,667	$ 66,667	$ -	$ 21,068	$ 21,068
29	2030	0.303		$ 66,667	$ 66,667	$ -	$ 20,218	$ 20,218
Total Alt 3			$ 330,400	$ 2,208,250	$ 2,538,650	$ 330,400	$ 1,355,789	$ 1,686,189